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ON CONSTRUCTIVISM

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Certainly we are all aware of the bleak report card that our nation's schools have received from various educational research organizations. In comparison to school children from other countries, American children lag far behind in achievements tests, especially those in the math and science areas (Raizen and Michelsohn, 1994). Unfortunately, the situation is even worse than it appears. Studies show that even students who score well on standardized tests often are unable to successfully integrate or contrast memorized facts and formulae with real-life applications outside the school room (Yager, 1991). L.B. Resnick (1987) has commented that practical knowledge (common sense) and school knowledge are becoming mutually exclusive; many students see little connection between what they learn in the classroom with real life.

Additionally, the traditional teaching method of teacher as sole information-giver to passive students appears outdated. In a Berkeley (Angelo, 1991) study on undergraduates in a large lecture hall setting, it was found that only 20 % of the students retained what the instructor discussed after the lecture. They were too busy taking notes to internalize the information. Also, after a lecture has passed eight minutes, only 15 % of the students are paying attention. Futhermore, Project 2061 (1990, p. xvii) charges that the "present curricula in science and mathematics are overstuffed and undernourished. They emphasize the learning of answers more than the exploration of questions, memory at the expense of critical thought, bits and pieces of information instead of understanding in context, recitation over argument, reading in lieu of doing. They fail to encourage students to work together, to share ideas and information freely with each other, or to use modern instruments to extend their intellectual capabilities."

One proposed solution for this problem is to prepare students to become good adaptive learners. That is, students should be able to apply what they learn in school to the various and unpredictable situations that they might encounter over the course of their worklives. Obviously, the traditional teacher-as-information-giver, textbook guided classroom has failed to bring about the desired outcome of producing thinking students. A much-heralded alternative is to change the focus of the classroom from teacher dominated to student-centered using a constructivist approach.

Constructivism is not a new concept. It has its roots in philosophy and has been applied to sociology and anthropology, as well as cognitive psychology and education. Perhaps the first constructivist philosopher, Giambatista Vico commented in a treatise

in 1710 that "one only knows something if one can explain it " (Yager, 1991). Immanual Kant further elaborated this idea by asserting that human beings are not passive recipients of information. Learners actively take knowledge, connect it to previously assimilated knowledge and make it theirs by constructing their own interpretation (Cheek, 1992).

Focusing on a more educational description of constructivism, meaning is intimately connected with experience. Students come into a classroom with their own experiences and a cognitive structure based on those experiences. These preconceived structures are either valid, invalid or incomplete. The learner will reformulate his/her existing structures only if new information or experiences are connected to knowledge already in memory. Inferences, elaborations and relationships between old perceptions and new ideas must be personally drawn by the student in order for the new idea to become an integrated, useful part of his/her memory. Memorized facts or information that has not been connected with the learner's prior experiences will be quickly forgotten. In short, the learner must actively construct new information onto his/her existing mental framework for meaningful learning to occur.

What are the underpinnings for a constructivist learning setting and how do they differ from a classroom based on the traditional model (sometimes referred to as the objectivist model)? The current American classroom, whether grade school or college level, tends to resemble a one-person show with a captive but often comatose audience. Classes are usually driven by "teacher-talk" and depend heavily on textbooks for the structure of the course. There is the idea that there is a fixed world of knowledge that the student must come to know. Information is divided into parts and built into a whole concept. Teachers serve as pipelines and seek to transfer their thoughts and meanings to the passive student. There is little room for student-initiated questions, independent thought or interaction between students. The goal of the learner is to regurgitate the accepted explanation or methodology expostulated by the teacher (Caprio, 1994).

In a constructivist setting, knowledge is not objective; mathematics and science are viewed as systems with models that describe how the world might be rather than how it is. These models derive their validity not from their accuracy in describing the real world, but from the accuracy of any predictions which might be based on them (Postlewaite, 1993). The role of the teacher is to organize information around conceptual clusters of problems, questions and discrepant situations in order to engage the student's interest. Teachers assist the students in developing new insights and connecting them with their previous learning. Ideas are presented holistically as broad concepts and then broken down into parts. The activities are student centered and students are encouraged to ask their own questions, carry out their own experiments, make their own analogies and come to their own conclusions.

The next part of this paper focuses on guidelines for becoming a constructivist teacher and methodologies for creating a constructivist classroom. Becoming a constructivist teacher may prove a difficult transformation since most instructors were prepared for teaching in the traditional, objectivist manner. It "requires a paradigm shift" and "requires the willing abandonment of familiar perspectives and practices and the adoption of new ones" (Brooks and Brooks, 1993, p. 25). The following represent a summary of some suggested characteristics of a constructivist teacher (Brooks and Brooks, 1993):

1. Become one of many resources that the student may learn from, not the primary source of information.

2. Engage students in experiences that challenge previous conceptions of their existing knowledge.

3. Allow student respones to drive lessons and seek elaboration of students' initial responses. Allow student some thinking time after posing questions.

4. Encourage the spirit of questioning by asking thoughtful, open-ended questions. Encourage encourage thoughtful discussion among students.

5. Use cognitive terminology such as "classify," "analyze", and "create" when framing tasks.

6. Encourage and accept student autonomy and initiative. Be willing to let go of classroom control.

7. Use raw data and primary sources, along with manipulative, interactive physical materials.

8. Don't separate knowing from the process of finding out.

9. Insist on clear expression from students. When students can communicate their understanding, then they have truly learned.

A teacher may structure a lesson in the following format which was condensed from current constructivist literature and is not intended to be a rigid set of rules. The first objective in a constructivist lesson is to engage student interest on a topic that has a broad concept. This may be accomplished by doing a demonstration, presenting data or showing a short film. Ask open-ended questions that probe the students preconceptions on the topic. Next, present some information or data that does not fit with their existing understanding. Let the students take the bull by the horns. Have students break into small groups to formulate their own hypotheses and experiments that will reconcile their previous understanding with the discrepant information. The role of the teacher during the small group interaction time is to circulate around the classroom to be a resource or to ask probing questions that aid the students in coming to an understanding of the principle being studied. After sufficient time for experimentation, the small groups share their ideas and conclusions with the rest of the class, which will try to come to a consensus about what they learned. Appendix I contains more ideas for employing a constructivist teaching approach.

Assessment can be done traditionally using a standard paper and pencil test, but there are other suggestions for evaluation. Each small group can study/review together for an evaluation but one person is chosen at random from a group to take the quiz for the entire group. The idea is that peer interaction is paramount when learners are constructing meaning for themselves, hence what one individual in the group has learned should be the same as that learned by another individual (Lord, 1994). The teacher could also evaluate each small group as a unit to assess what they have learned.

Clearly, a lesson based on constructivism differs greatly from the traditional "teacher-as-lecturer" class type. The effectiveness of the constructivist method has been evaluated and a few studies will be summarized. In one evaluation (Caprio, 1994),

the constructivist approach was employed and compared to the traditional lecture-lab format for the second semester of a two-semester anatomy and physiology sequence in a community college. The two student groups were matched for academic ability and prerequisites. Both courses were night classes and most of the students were hoping to major in health-career programs. The testing instrument was the first exam. The same exam was given to both sets of students at midterm. A drawback to the study was that the two groups were studied seven years apart. The results showed that better exam grades were obtained by students taught by the constructivist methodology. The average exam score for the constructivist group was 69.7% (N = 44) while that taught by the traditional lecture-lab method was 60.8 % (N = 40). A t-test showed that the grade difference was significant ($p > 0.99$).

Caprio also offered many personal insights on his perception of student learning. The students in the constructivist group seemed more confident of their learning and he gave them more material for independent learning. The investigator found that this was necessary since constructive teaching methods are more time-consuming. This was done only with secondary topics. The students in the constructivist class seemed to like class better, had more energy and took more responsibility for their learning.

Another (Carey, 1989) constructivist study probed the nature of student views on scientific inquiry. Despite instruction in the scientific method in the traditional mode, many students do not understand the nature or purpose of scientific inquiry. Science is seen as a random activity that has little meaning in real life. Grade 7 students were rated by interviews on a scale of 1 to 3 about their conception of how science is investigated before and after a constructivist style learning unit on the topic. Prior to the unit, most students fell in the Level 1 category. Level 1 students view science as a way of understanding facts about the world. After the learning unit, most of the students had moved to a Level 2 understanding; they saw scientific inquiry as being guided by questions and ideas. The also understood the difference between an idea and an experiment. Level 3 understanding was achieved only by a few students. At this level, the student understands the cyclic, cumulative nature of science and recognizes the goal of science as the construction of deeper explanations of the universe.

In summary, contructivist teaching offers a bold departure from traditional objectivist classroom strategies. The goal is for the learner to play an active role in assimilating knowledge onto his/her existing mental framework. The ability of students to apply their school-learned knowledge to the real world is valued over memorizing bits and pieces of knowledge that may seem unrelated to them. The constructivist approach requires the teacher to relinquish his/her role as sole information-dispenser and instead to continually analyze his/her curriculum planning and instructional methodologies. Perhaps the best quality for a constructivist teacher to have is the "instantaneous and intuitive vision of the pupil's mind as it gropes and fumble to grasp a new idea" (Brooks and Brooks, 1993, p. 20). Clearly, the constructivist approach opens new avenues for learning as well as challenges for the teacher trying to implement it.

Appendix I

More ideas on implementing a constructivist format.

A. The following procedures for teachers are suggested by Yager (1991):

1. Seek out and use student questions and ideas to guide lessons and whole instructional units.

2. Accept and encourage student initiation of ideas.

3. Promote student leadership, collaboration, location of information and taking actions as a result of the learning process.

4. Use student thinking, experiences and interests to drive lessons.

5. Encourage the use of alternative sources for information both from written materials and experts.

6. Encourage students to suggest causes for event and situations and encourage them to predict consequences.

7. Seek out student ideas before presenting teacher ideas or before studying ideas from textbooks or other sources.

8. Encourage students to challenge each other's conceptualizations and ideas.

9. Encourage adequate time for reflection and analysis; respect and use all ideas that students generate.

10. Encourage self-analysis, collection of real evidence to support ideas and reformulation of ideas in light of new knowledge.

11. Use student identification of problems with local interest and impact as organizers for the course.

12. Use local resources (human and material) as original sources of information that can be used in problem resolution.

13. Involve students in seeking information that can be applied in solving real-life problems.

14. Extend learning beyond the class period, classroom and the school.

15. Focus on the impact of science on each individual student.

16. Refrain from viewing science content as something that merely exists for students to master on tests.

17. Emphasize career awareness--especially as related to science and technology.

B. Also offered by Yager (1991) are these strategies for implementing a constructivist lesson.

1. Starting the lesson	Observe surroundings for points to question. Ask questions. Consider possible responses to questions. Note unexpected phenomena. Identify situations where student perceptions vary.

2. Continuing the lesson	Engage in focused play. Brainstorm possible alternatives. Look for information. Experiment with materials. Observe a specific phenomena . Design a model. Collect and organize data. Employ problem-solving strategies. Select appropriate resources. Students discuss solutions with others. Students design and conduct experiments. Students evaluate and debate choices. Students identify risks and consequences. Define parameters of an investigation.
3. Proposing explanations & solutions	Communicate information and ideas. Construct and explain a model. Construct a new explanation. Review and critique solutions. Utilize peer evaluation. Assemble appropriate closure. Integrate a solution with existing knowledge and experiences
4. Taking action	Make decisions Apply knowledge and skills. Transfer knowledge and skills. Share information and ideas. Ask new questions. Develop products and promote ideas. Use models and ideas to illicit discussions and acceptance by others.

C. The following is a checklist that a teacher can utilize to determine the degree of constructivist learning in their classroom vs. a more traditional, objectivist approach (Yager, 1991, p. 56).

More Objectivist		More Constructivist
Teacher	DENTIFIES THE ISSUE/TOPIC	Student
No	ISSUE IS SEEN AS RELEVANT	Yes
Teacher	ASKS THE QUESTIONS	Student
Teacher	IDENTIFIES WRITTEN AND HUMAN RESOURCES	Student
Teacher	LOCATES WRITTEN RESOURCES	Student
Teacher	CONTACTS NEEDED HUMAN RESOURCES	Student
Teacher	PLANS INVESTIGATION AND ACTIVITIES	Student
No	VARIED EVALUATION TECHNIQUES USED	Yes
No	STUDENTS PRACTICE SELF-EVALUATION	Yes
No	CONCEPTS AND SKILLS APPLIED TO NEW SITUATIONS	Yes
No	STUDENTS TAKE ACTION(S)	Yes

No	SCIENCE CONCEPTS AND PRINCIPLES EMERGE BECAUSE THEY ARE NEEDED	Yes
No	EXTENSIONS OF LEARNING OUTSIDE THE SCHOOL IN EVIDENCE	Yes

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