Socrates

Education and Culture

Socrates - Comenius 2-1-2006-1

Improving Quality of Science Teacher Training in European Cooperation - constructivist approach (IQST)

Development Procedural Skills in Science Education – constructivist approach

Unit 1

Scientific and technology literacy. Components and level of scientific literacy

Objectives: After working on this topic students will:

- **be able to interpret the meaning of STL in the context of physics teaching**
- **know some historical data related to the development of STL**
- **be able to indicate some taxonomy for assessing the development of STL among high school students;**
- **be able to give the definition of STL**
- **know some statements of the critic to STL**
- **be able to name the levels of STL**
- **be able to state the definition of the levels of STL**
- **be able to give examples for the levels in the context of physics education.**

Definition of STL

Scientific literacy, quite simply, is a mix of concepts, history, and philosophy that help you understand the scientific issues of our time.

- Scientific literacy is not the specialized, jargon-filled esoteric lingo of the experts. You don't have to be able to synthesize new drugs to appreciate the importance of medical advances, nor do you need to be able to calculate the orbit of the space station to understand its role in space exploration.

Scientific literacy is rooted in the most general scientific principles and broad knowledge of science; the scientifically literate citizen possesses facts and vocabulary sufficient to comprehend the context of the daily news.

"Scientific literacy" is the knowledge and understanding of scientific concepts and processes required for personal decision making, participation in civic and cultural affairs, and economic productivity. People who are scientifically literate can ask for, find, or determine answers to questions about everyday experiences. They are able to describe, explain, and predict natural phenomena.

Holbrook:

It is not possible to give an all encompassing definition of STL. STL is much more the gaining of body of knowledge and a way of knowing. It is more than being aware of applications of science, or developing a positive attitude towards science. In fact it is not so much about science as it is about gaining a meaningful education through a context of science. It definitely encompasses good teaching practices and hence the professional development of teachers is seen as an essential component in its promotion.
STL can be put forward to mean “developing the ability to creatively utilize sound science knowledge (and ways of working) in energy life to solve problems make decisions and hence improve the quality of life” This is based on acquiring educational skills at the intellectual, attitudinal, communicative, societal and interdisciplinary levels.
If the above represents the target, then STL within formal schooling van be defined as “that science education which is intended within school curriculum to maximize its role in aiding students to acquit the goals of general education, as stipulated by society within a country”. In other words, science is taught in schools, because it is seen as an important part of general education.
It is important that STL should not be viewed as a constant target. It differs, depending on education received and the educational objectives stipulated at a given educational level within a specific country.
PISA gives another definition of scientific literacy – “the ability to use scientific knowledge, to identify questions and make conclusions based on evidence, so as to understand and support decision making related to nature and human induced changes in it.”

Some historical roots of STL

Expressions of the need for education in the sciences have a long history dating back to the emergence of science as a definable style of inquiry. Hurd (1997) described a progression of calls for science education beginning with Francis Bacon in 1620 and advancing on through the writings of Benjamin Franklin, Thomas Jefferson, Herbert Spencer and on into the 20th century. After examining this period, though, some historians argue that in spite of these calls, science was not a topic taught to students in the highest levels of academic pursuit, at least in secondary school.

Tolley (1996) has shown that science was not a primary feature of the advertised curriculum of private academies for men during the first half of the 19th century, but rather was more frequent component of curricula in private schools for women. Her analysis demonstrated that the curricula of schools for men were dominated by the studies of classics, while science was a more prevalent feature in schools for women. For instance, during the period of 1800 - 1840 in private schools in North Carolina and Virginia, natural philosophy was taught in 74% of girls' schools while only appearing in the curricula of 47% of schools for boys. This trend was equally evident for schools in other areas of the country. She concluded that: Although parents may not have considered the sciences quite good enough for their sons, they viewed them as acceptable for their daughters. The most important factor in the rise of scientific subjects in girls' schools is the novelty of the institutions themselves. Unlike boys' academies, which were preceded by the Latin grammar schools, there was no precedent for the curriculum in female seminaries. As a result, educational reformers seeking to bring the sciences into secondary schools were far more likely to succeed in girls' schools.

Hurd (1997) cited two important mid-19th century contributions to the development of the importance of science education for all people. During a lecture in 1847 titled "Science for All," James Wilkinson expressed the opinion that scientists were "unconcerned with relating the findings in the business of life'", but Wilkinson began to forward the cause of science for the public. The second contribution was from Herbert Spencer, who in an essay titled "What Knowledge is Most Worth Knowing?" described "school science courses as consisting mostly of dead facts' that fail to make clear that they can produce appreciable effects on human welfare".

These two examples, added to Tolley's analysis of school curricula, contribute to the view that at the middle of the 19th century, science was not widely viewed as knowledge that was worthy of study for the majority of students. The idea of "science for all," however, did begin to take hold as the 19th century drew to a close. With this, a conception of scientific literacy began to emerge.

> One writer who presaged modern notions was the physicist, psychologist, and philosopher Ernst Mach. In 1898, he published a book titled *Popular Scientific Lectures* in which, among other things, he was critical of the classical education which had predominated in schools. To this end, he wrote: "One inclined to be uncharitable might say that our gymnasiums and classical academies turn out men who can speak and write, but, unfortunately, have little to write or speak about" . Mach also offered a notion of scientific *il*literacy that is very much in tune with the train of thought that has progressed to this day.
> These sentiments were expanded even further by R. A. Millikan in 1917. At that time, Millikan was one of the United States' most notable scientists and had received the Nobel Prize for his famous Oil Drop experiment of 1913.
> Millikan described science as the "taproot of the tree of human progress," but he did
> Interestingly, this observation brought him to the same conclusion as the philosopher and historian, Henry Adams. There was one very large difference, however. Adams, recognizing himself as scientifically illiterate, was dismayed rather than exultant at the fact.

This historical review traces a long progression of calls for science in the education of people. Various scientists and educators have expanded the call to include the need for science for all people. But with all these calls there is a continuing expression that the science in the education is not adequate and that an education of "inert facts" is an education about something other than science. The heart of science instruction lies in learning about process, origins, and knowing in science. Its essence is found in *how* we know, not in *what* we know.

As noted in the anecdotal account above, Adams, at the turn of the last century, implicitly operationally defined education not as the extent of schooling or the volume of declarative knowledge (both of which he himself possessed in abundance) but as the meaningfulness and comprehensibility of new experiences which may or may not result. At the same time one of his contemporaries, the philosopher of education, John Dewey, was turning this basic insight into more rigorously codified principles which we will argue are very relevant to the concept of scientific literacy today.

3.3. Components and levels of scientific literacy

The possibility levels of STL

- Normal STL: Students identify terms and concepts as being scientific in nature, but that they have misconception and can only provide native explanations of scientific concepts.
- Functional STL : Students can describe a concept but have a limited understanding of it. School examinations are renown for testing this level.
- Structural STL: Students develop personal relevance and are interested in the study of a science concept and construct appropriate meaning of the concept from experiences.
- Multi- dimensional STL: Students understand the place of science among other disciplines, know the history and nature of science, and understanding the interactions between science and society. The multidimensional level pf literacy and retain the need to know, and have acquired the skills to ask answer appropriate questions.

The STL Philosophy
This is based on Science Education being

a) treated as part of education;
b) approached from a societal perspective;
c) based on Constructivists principles.

<u>STL features</u>
The definitions given contain the following STL common features

- the ability to act confidently in relation to the scientific aspects of the surrounding world
- the ability to consider things from a scientific point of view, for instance, whether in explaining an event or a phenomenon evidence has been taken into consideration
- the possibility to feel confidence in the essence of STL and to understand their limitations an benefits

<u>STL components</u>
There are three STL components

- Notions and ideas that help us understand the surrounding world and make it possible for us to relate our new experience to what we already know;
- Processes related to mental and physical skills necessary to acquire, interpret and use data and evidence from the surrounding world;
- Relations or inclination that indicate willingness and confidence in involving in research, debate or further studies.

The relation of STL with the content based teaching standards in the countries

National Science Education Standards, Content Standard Categories are fully described in the documents at http://www.minedu.government.bg/opencms/opencms/left_menu/documents/

Tasks (assignments)

1. Tell us about your understanding of STL
2. Name the most important historic facts related to STL
3. Define the possible components and levels of STL
4. Taking into consideration the established standards in education related to the teaching of physics in Bulgaria, try to evaluate to what extent they are directed towards (correspond to) STL

Case study

In class students should understand the notion of STL and be able to use it in describing the study of physics. They study the State educational standards on contents and comment the ideas related to STL set in them.

Questions to Case Study

What does STL mean to you?

Do you agree that the STL component are enough and should drive science education put forward?

What you agree that only the 4th level is the real target for science teaching? Why?

What does teaching STL involve?

Is STL teaching appropriate?

Summary

The ability to use scientific knowledge, to identify questions and make conclusions based on evidence, so as to understand and support decision making related to nature and human induced changes in it. Science literacy was first mentioned in the 17-th century and the notion of it has been developed and enriched ever since. There are different levels of science literacy: normal, functional, structural, multy-demensional. There are tree science literacy components: notions and ideas, process related to mental and physical skills, relations to involving in research, debate or further studies.

Frequently Asked Questions

Next Reading

http://www.library.ucsb.edu/istl/00-winter/article2.html

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UNIT 2

CONSTRUCTIVIST APPROACH IN SCIENCE EDUCATION

Chapter Objectives:

Upon the completion of the topic students should:

- **know the main concepts of the constructivist theory so that be able to read and understand pedagogic literature and use their knowledge in their lesson preparation and in the description of pedagogic tasks;**
- **know the main historic details in the development of this theory and the main ideas of some of its creators;**
- **know some of constructivist theories;**
- **be able to name some of constructivist methods and approaches;**
- **be able to describe the role of the teacher according to the constructivist theory;**
- **know some of the constructivist ideas on teaching environment, new media and textbooks;**
- **interpret evaluation according to the constructivist views.**

Why Is Constructivism Important?

In the last years constructivism as an approach in education has a central position in didactical literature. The number of scientific articles and books on constructivism as a theory and as an approach in the education is huge.

It is used in developing the educational standards in a number of states in the US and its use in teaching is highly recommended.

Constructivist theory is definitely accepted as a modern and leading theory in the teaching of science. Constructivism has become the most valuable guiding principle for the teachers of science, as well as for researchers in this field.Duit, R. The constructivist view in science education -- what it has to offer and what should not be expected from it, http://www.if.ufrgs.br/public/ensino/N1/3artigo.htm]

One component of the current redevelopment of all subject area curricula is the change in focus of instruction from the transmission curriculum to a transactional curriculum. In a traditional curriculum, a teacher transmits information to students who passively listen and acquire facts. In a transactional curriculum, students are actively involved in their learning to reach new understandings.

Constructivist teaching fosters critical thinking and creates active and motivated learners. The constructivist theory be incorporated into the curriculum, and advocate that teachers create environments in which children can construct their own understandings . Twomey Fosnot (1989) recommends that a constructivist approach be used to create learners who are autonomous, inquisitive thinkers who question, investigate, and reason. A constructivist approach frees teachers to make decisions that will enhance and enrich students' development" in these areas.

What is constructivism?

– Definition:

Constructivism is a view of learning based on the belief that knowledge isn't a thing that can be simply given by the teacher at the front of the room to students in their desks. Rather, knowledge is constructed by learners through an active, mental process of development; learners are the builders and creators of meaning and knowledge

“Constructivism" is a philosophical viewpoint on how the mind forms and modifies its understanding of reality. It is the foundation of our outlook on pedagogy and research.

In what way is a constructivist view of science education different from other views? The answer lies in the tenets of constructivist *philosophy,* which assert that all knowledge is constructed as a result of cognitive processes within the human mind. While this may appear to be a harmless enough statement, many find (so-called) *radical* constructivism somewhat unpalatable. Radical constructivism challenges the notion of an external reality: No amount of stimuli, experience, or thinking is sufficient to *prove* the existence of an external agent. Science (of course) *presumes* such an external reality and seeks to describe its nature and behavior. (Science also presumes that the external reality is well behaved and capable of being explained.)

The premises of constructivism as an epistemology are:

1. Knowledge is constructed, not transmitted.
2. Prior knowledge impacts the learning process.
3. Initial understanding is local, not global.
4. Building useful knowledge structures requires effortful and purposeful activity.

For pedagogic purposes, the tenets of constructivism can be rephrased as follows:

1. Students come into our classrooms with an established world-view, formed by years of prior experience and learning.
2. Even as it evolves, a student's world-view filters all experiences and affects their interpretation of observations.
3. Students are emotionally attached to their world-views and will not give up their world-views easily.
4. Challenging, revising, and restructuring one's world-view requires much effort.

If we base instruction on the principles of constructivism, the role of the teacher is raised from someone who simply dispenses information to someone who structures activities that improve communication, that challenge students' pre-conceived notions, and that help students revise their world-views. In spite of the difficulties, cognitive research has been able to identify important patterns in the ways students and experts think about their subjects, suggesting pedagogic practices that enhance learning.

– Types of constructivism:

"The psychological theory of constructivism came from Jean Piaget and Lev Vygotsky. Widespread interests of this theory have led to a debate between those who place more emphasis on the individual cognitive structuring process and those who emphasize the social effects on learning" (Fosnot, 1996). The terms "cognitive constructivism" and "social constructivism" have become common when talking about this psychological theory. Social Constructivism and Cognitive Constructivism are two types of constructivism.

Cognitive Constructivism

It is based on the work of developmental psychologist Jean Piaget. Piaget's theory has two major parts: an "ages and stages", which predicts what children can and cannot understand at different ages, and a theory of development that describes how children develop cognitive abilities (Chambliss, 1996). The theory of development is the major foundation of cognitive constructivist approaches to teaching and learning. Piaget's theory of cognitive development suggests that humans cannot be "given" information which the automatically understand and use, they must "construct" their own knowledge. They have to build their knowledge through experience. Experiences allows them to create mental images in their head . Cognitive prospective theories focus on both what students learn and the process by which they do so (Fosnot, 1996).

Social Constructivism

. It is a theory developed by psychologist Lev Vygotsky. Vygotsky's theory is very similar to Piaget's assumptions about how children learn, but Vygotsky places more emphasis on the social context of learning. Also, in Piaget's theory, the teacher plays a limited role where as in Vygotsky's theory the teacher plays a very important role in learning. There is much more room for an active, involved teacher. Social constructivism argues that students can, with help from adults or children who are more advanced, grasp concepts and ideas that they cannot understand on their own. Unlike cognitive constructivism, teachers in social constructivism do not just stand by and watch children explore and discover. The teacher may guide students as they approach problems, may encourage them to work in groups to think about issues an questions, and support them with encouragement and advice.

There is a great deal of overlap between cognitive constructivism and social constructivism., but there is also a great deal that is different. Cognitive theorists might argue that social theories do not adequately account for the process of learning , and social theorists might report that cognitive theories fail to account for the production and reproduction of the practices of schooling and the social order (Fosnot, 1996).

Radical constructivism

In science (and mathematics) education von Glasersfeld's radical constructivism (von Glasersfeld, 1989, 1992, in press) is most often employed as reference position of the constructivist view. Radical constructivism deliberately is an epistemology, a theory of knowledge, more precisely a theory of "experiential" knowledge. This knowledge is seen as tentative human construction on the basis of the already existing knowledge. The tentative, provisional character of experiential knowledge is of great importance. It leads to the denial that there may be ultimate truth for this kind of knowledge. That there may be such a kind of truth in the field of religious beliefs, however, is not questioned. The tentative character concerns every kind of experiential knowledge, knowledge constructed by the individual and science knowledge as well. Also the latter is viewed as human construction on the basis of the conceptions and ideas the individual scientist or the respective scientific community holds.

There are three key principles of radical constructivism. The first states that *knowledge is not passively received but is built up by the cognizing subject*. According to this principle it is not possible to transfer ideas into students' heads intact, rather students construct their own meanings from the words or visual images they hear or see. What the learners already know is of key importance in this construction process.

The second principle states that *the function of cognition is adaptive and enables the learners to construct viable explanations of experiences.* Knowledge of the world outside, hence, is viewed as human tentative construction. A 'reality' outside is not denied but it is only possible to know about that reality in a personal and subjective way. There is sometimes the misunderstanding that this principle argues in favor of "anything goes" so to speak, that every human construction is allowed. This is definitely not the case. The constructions have to be "viable". This term is based on an analogy to the development of the species in evolution. Only those species "survive" that are adapted best to the environment. Per analogicam: only those constructions are "viable" that prove to be useful for the constructor.

Von Glasersfeld likes to call the first principle the trivial constructivist principle in order to lead attention to the crucial importance of the second one. But the term "trivial constructivism" appears to be "ill-chosen" (Ernest, 1993; see similar arguments by Solomon, 1994, 14). First, it is far from being trivial to put this principle into practice as will be outlined below. Secondly, there are strong logical relations between the two principles. The key idea is in some way already in the first principle, the second one may well be viewed as a further elaboration of the first.

Radical constructivism as proposed by von Glasersfeld implicitly includes a third principle. It highlights that although individuals have to construct their own meaning of a new phenomenon or idea, *the process of constructing meaning always is embedded within a social setting of which the individual is part.*

– **Essence of constructivism**:

Principles of Learning

Constructivism is a theory about learning, not a description of teaching. Learners construct knowledge for themselves. Each learner individually constructs meaning as he or she learns. There are nine general principles of learning that are derived from constructivism. These nine principles are: (1) learning is an active process in which the learner uses sensory input and constructs meaning out of it, (2) people learn to learn as they learn. Learning consists both of constructing meaning and constructing systems of meaning. (3) Physical actions and hands on experience may be necessary for learning, especially for children, but is not sufficient; we need to provide activities which engage the mind as well as the hand. Dewey called this reflective activity. (4) Learning involves language: the language that we use influences our learning. Lev Vygotsky, a psychologist that helped in the theory of constructivism, argued that language and learning are inextricably intertwined. (5) Learning is a social activity: our learning is intimately associated with our connection with other human beings, our teacher, our peers, our family, as well as casual acquaintances. Dewey pointed out that most of traditional learning is directed toward isolating the learner from social interaction, and towards seeing education as a one-on-one relationship between the learner and the objective material being learned. (6) Learning is contextual: we learn in relationship to what else we know, what we believe, our prejudices and our fears. (7) One needs knowledge to learn: it is not possible to absorb new knowledge without having some structure developed from previous knowledge to build on. The more we know, the more we learn. (8) Learning is not instantaneous: it takes time to learn. For significant learning we need to revisit ideas, ponder them, try them out, play with them, and use them. (9) The key component to learning is motivation. (Constructivist Learning Theory,2002). "Education is about using knowledge, not acquiring it" (Vermette, Foote, Bird, Mesibow, Harris-Ewing, & Battaglia, 2001). "Constructivism is a psychological theory that construes learning as an interpretive, recursive, building process by active learners interacting with the physical and social world" (fosnot, 1996,).

On the common core of the constructivist view as used in science education

In summarizing what has been presented above it has to be stated another time that the constructivist view primarily concerns a particular theory of knowledge and knowledge acquisition. Consequences drawn from this view for science teaching and learning in general that are usually discussed under headings like "constructivist science instruction" go far beyond epistemological issues and issues of knowledge acquisition. As will be outlined in more detail below they mostly concern the arrangement of conditions that support students' constructions on the basis of their already existing knowledge. There appear to be four main facets of the view of knowledge under review here.

(1) *Active construction on the basis of the already existing conceptions*. Students have to construct the new knowledge actively by themselves on the grounds of the already existing knowledge. There is no learning from scratch, there is no simple transfer of pieces of knowledge from a certain source to the learner. The already existing knowledge (students' prior conceptions) have proven to be both the necessary building blocks and empediments of learning. As will be discussed below many students' prior science conceptions are in stark contrast to the science conceptions to be learned (compare the list of key findings of students' conceptions research in the appendix). Changing from these conceptions to science conceptions is not easy, sometimes not even likely, because the already existing conceptions provide the goggles, so to speak, for seeing the new conceptions presented by the teacher, a textbook or the like. Ausubel's (1968, vi) famous dictum "The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly" points to the key importance of the already existing knowledge. The more recent developments in constructivist oriented science education research have revealed what the learner already knows in major science domains, and have also led to the development and evaluation of new approaches to what "teach him accordingly" may mean.

(2) *Tentative construction* . All knowledge or ideas constructed by the individual about traits of the world outside or about ideas another may have is tentative in nature. It is hypothetical and may need minor or major changes when other evidences become available. Also science knowledge as accepted today in scientific communities in principle is tentative in nature and open for revision.

(3) *Viability*. Knowledge and ideas that have been constructed need to be viable, i.e., useful for the individual (or a group of individuals respectively). Students may, for instance, construct what they like but then they run the risk of not being understood by others. Only constructs that stand the test of being viable survive so to speak.

(4) *Social construction*. Although every individual has to construct knowledge by her or himself the construction process always also has a social component. Knowledge is always constructed within a certain social setting.

The constructivist view though still in need of further refinements has proven to be a most valuable (viable) guide for student centred pedagogy in science education, i.e., for science education that is oriented towards the needs and interests of students. In the following, first key findings of research on students' conceptions in science that clearly show the importance of prior knowledge as determining factor in learning will be outlined. Afterwards characteristics of new constructivist approaches of science instruction and of teacher education will be presented.

Historic periods in the development of constructivism and major scientists in the field

Constructivism draws on the develomental work of Piaget (1977) and Kelly (1991). Twomey Fosnot (1989) defines constructivism by reference to four principles: learning, in an important way, depends on what we already know; new ideas occur as we adapt and change our old ideas; learning involves inventing ideas rather than mechanically accumulating facts; meaningful learning occurs through rethinking old ideas and coming to new conclusions about new ideas which conflict with our old ideas. A productive, constructivist classroom, then, consists of learner-centered, active instruction. In such a classroom, the teacher provides students with experiences that allow them to hypothesize, predict, manipulate objects, pose questions, research, investigate, imagine, and invent. The teacher's role is to facilitate this process.

Important People in the Development of the Theory of Constructivism

John Dewey

Many psychologists worked on the theory of constructivism, but John Dewey was one of the first major contemporaries to develop this theory. According to him education depended on action. For Dewey, mind is a means of transforming, reorganizing, reshaping accepted meanings and values, a means of attending to “the lived situations of life.” Dewey kept telling his readers, “Mind is active, a verb and not a noun“ (fosnot, 1996, p.126). Dewey stressed the importance of having a student’s knowledge grow from experience. Knowledge and ideas came only from a situation where learners had to draw them out of experiences that had meaning and importance to them. These situations, according to Dewey, have to occur in a social environment, where students could come together to analyze materials and to create a community of learners who built their knowledge together (Building an Understanding of Constructivism,1995).

Jean Piaget

Jean Piaget was another one of the psychologists who had a great influence on the theory of constructivism. Piaget was very interested in the way that children think. Piaget's constructivism was based on his view of the psychological development of children. He believed that the fundamental basis of learning was discovery: "To understand is to discover, to reconstruct by rediscovery, and such conditions must be complied with if in the future individuals are to be formed who are capable of production and creativity and not simply repetition." According to Piaget, to reach an understanding of basic phenomena, children have to go through stages in which they accept ideas they may later see as not truthful. Understanding is built up step by step through active involvement (Building an Understanding of Constructivism,1995)."The focus of Piaget's theory is the various reconstructions that an individual's thinking goes through in the development of logical reasoning" (Green & Gredler, 2002).

In 1977 Piaget asserts that learning occurs by an active construction of meaning, rather than by passive recipience. He explains that when we, as learners, encounter an experience or a situation that conflicts with our current way of thinking, a state of disequilibrium or imbalance is created. We must then alter our thinking to restore equilibrium or balance. To do this, we make sense of the new information by associating it with what we already know, that is, by attempting to assimilate it into our existing knowledge. When we are unable to do this, we accommodate the new information to our old way of thinking by restructuring our present knowledge to a higher level of thinking.

Lev Vygotsky

A third view of constructivism was developed by Lev Vygotsky. Vygotsky believed that children learn concepts from their everyday notions and adult concepts. He says that students learn through interacting with their peers, teacher, manipulative, and their contextual setting (Jaramillo, 1996). When the child is presented with a preformed concept from the adult world, they will only memorize what the adult says about the idea. The child then works out their own ideas from the generalization that they have already and that they had been introduced to (Building an Understanding of Constructivism,1995). Vygotsky felt that the students need to be guided by adults, but he also thought that it was very important for the student to be influenced by their peers as well as discover things on their own.

Jerome Bruner

Along with the previous psychologists mentioned, Jerome Bruner also had a big influence on the theory of constructivism. Bruner's major ideas were that learning was an active, social process in which students construct new ideas or concepts based on their current knowledge. He also said that the instructor should try and encourage students to discover principles by themselves (Jerome Bruner200l). Bruner's feelings were that the curriculum should be organized in a spiral manner so that students continually build upon what they already know.

Constructivist teaching strategies

– **the new role of the teacher:**

The role of the teacher and the classroom environment are important parts of Piaget's theory. The role of the teacher is to provide a classroom full of interesting things to encourage the child to construct their own knowledge and to have the ability to explore. The classroom must give the students the opportunity to construct knowledge through their own experiences. They cannot be "told" by the teacher. There is less emphasis on directly teaching specific skills and more emphasis on learning in a meaningful context

One of the primary goals of using constructivist teaching is that students learn how to learn by giving them the training to take initiative for their own learning experiences.

According to Audrey Gray, the characteristics of a constructivist classroom are as follows:

- the learners are actively involved
- the environment is democratic
- the activities are interactive and student-centered
- the teacher facilitates a process of learning in which students are encouraged to be responsible and autonomous

In the constructivist classroom, the teacher's role is to prompt and facilitate discussion. Thus, the teacher's main focus should be on guiding students by asking questions that will lead them to develop their own conclusions on the subject.

David Jonassen identified three major roles for facilitators to support students in constructivist learning environments:

- Modeling
- Coaching
- Scaffolding

The role of the teacher and the classroom environment are important parts of Piaget's theory. The role of the teacher is to provide a classroom full of interesting things to encourage the child to construct their own knowledge and to have the ability to explore. The classroom must give the students the opportunity to construct knowledge through their own experiences. They cannot be "told" by the teacher. There is less emphasis on directly teaching specific skills and more emphasis on learning in a meaningful context.

Becoming a Constructivist Teacher

All of these psychologists, who had major influences on the theory of constructivism, felt that the teacher was a very vital part of the theory. A constructivist teacher sets up problems and monitors students exploration, guides the direction of student inquiry and promotes new patterns of thinking (Brooks & Brooks, 1995). It is up to the teacher to facilitate the constructivist learning process. The structure of the learning environment should promote opportunities and events that encourage and support the process of understanding.

We have all been in a classroom where the teacher asks a question to the students and hands fly up excitedly because the student feels that they know the answer. The teacher then looks around the room and chooses a student. The student answers, and the teacher says, “No”. The teacher then calls on another student who answers and the teacher says, “Close but not quite.” The teacher then proceeds to call on a third student who answers and then teacher replies, “Yes, that is the right answer!”

The teacher conveys many lessons to the students by conducting their classroom in this manner. The student now knows that there is one answer to the teachers questions and that they have to find that one right answer. Another thing is that the student now knows that they put themselves at risk if they raise their hand, unless they are certain that they have to right answer. The teacher should respond to the student’s answers by saying, “Gee, I never thought of it that way” or “That is a creative way of looking at it.”

The teacher’s response “No”, causes the students to feel foolish. The teacher needs to encourage the student and support them. This is the idea of constructivism and what it means to be a constructivist teacher. The purpose of a constructivist teacher is to make the students think for themselves, and not to wait for the teacher to tell then what to think. In traditional classrooms the teacher seeks the correct answer to validate student learning, where as in a constructivist classroom the teacher seeks the students point of view (Brooks & Brooks, 1999). The students will learn to proceed with less focus and direction from the teacher. With a constructivist teacher the students can express their own ideas clearly in their own words and not have to respond to restricted question.

– the constructivist model of teaching environment;

Constructivist Learning Environments

Jonassen has proposed a model for developing constructivist learning environments around a specific learning goal. This goal may take one of several forms, from least to most complex:

- Question or issue
- Case study
- Long-term Project
- Problem (multiple cases and projects integrated at the curriculum level)

Learning is driven in constructivist learning environments by the problem to be solved; students learn content and theory in order to solve the problem. This is different from traditional objectivist teaching where the theory would be presented first and problems would be used afterwards to practice theory.Depending on students' prior experiences, related cases and scaffolding may be necessary for support. Instructors also need to provide an authentic context for tasks, plus information resources, cognitive tools, and collaborative tools.

Creating a constructivist classroom

Along with having a constructivist teacher you also need to have a constructivist classroom. "Creating a constructivist classroom requires that the classroom teacher must be in position to: (1) Influence or create motivating conditions for students, (2) Take responsibility for creating problem situations,… (3) Foster acquisition and retrieval of prior knowledge…, and (4) Create a social environment that emphasizes that attitude of learning to learn,… The learning process not the product of learning is the primary focus of constructivism…"(Olsen, 1999, p2). The constructivist teacher has to guide and not tell. The student has to make their own meanings and decisions. They are not to be handed to them by the teacher. To facilitate real learning, teachers need to organize their classroom and their curriculum so that students can collaborate, interact, and raise questions of both classmates and the teacher.

The whole idea of a constructivist classroom is characterized by the mutual respect between the teacher and the children. In most classrooms the respect is one way. The children have to respect the teacher. A constructivist teacher respects the children by allowing the children rights to their feelings, ideas, and opinions. The teacher refrains from using their power unnecessarily. A characteristic of constructivist education is that the responsibility for decision making is shared by everyone in the classroom (De Vries & Zan, 1995).

Examples of constructivist activities

Furthermore, in the constructivist classroom, students work primarily in groups and learning and knowledge are interactive and dynamic. There is a great focus and emphasis on social and communication skills, as well as collaboration and exchange of ideas. This is contrary to the traditional classroom in which students work primarily alone, learning is achieved through repetition, and the subjects are strictly adhered to and are guided by a textbook. Some activities encouraged in constructivist classrooms are:

- Experimentation: students individually perform an experiment and then come together as a class to discuss the results.
- Research projects: students research a topic and can present their findings to the class.
- Field trips. This allows students to put the concepts and ideas discussed in class in a real-world context. Field trips would often be followed by class discussions.
- Films. These provide visual context and thus bring another sense into the learning experience.
- Class discussions. This technique is used in all of the methods described above. It is one of the most important distinctions of constructivist teaching methods.

Arguments against constructivist teaching techniques

A wide variety of authors from many fields have voiced the following arguments against constructivist based teaching instruction:

- A group of cognitive scientists has also questioned the central claims of constructivism, saying that they are either misleading or contradict known findings.

- One possible deterrent for this teaching method is that, due to the emphasis on group work, the ideas of the more active students may dominate the group's conclusions.

- Zhu and Simon (1987) state that because the emphasis is not based on acquiring and practicing basic skills, students in constructivist classrooms tend to lag behind those in traditional classrooms in these areas.

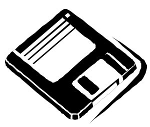
While proponents of constructivism argue that constructivist students perform better than their peers when tested on higher-order reasoning, the critics of constructivism argue that this teaching technique forces students to "reinvent the wheel." Supporters counter that "Students do not reinvent the wheel but, rather, attempt to understand how it turns, how it functions." Proponents argue that students — especially elementary school-aged children — are naturally curious about the world, and giving them the tools to explore it in a guided manner will serve to give them a stronger understanding of it.

Mayer (2004) developed an literature review spanning fifty years and concluded "The research in this brief review shows that the formula constructivism = hands-on activity is a formula for educational disaster." His argument is that active learning is often suggested by those subscribing to this philosophy. In developing this instruction these educators produce materials that require learning to be behaviorally active and not be "cognitively active." That is, although they are engaged in activity, they may not be learning (Sweller, 1988). Mayer recommends using guided discovery, a mix of direct instruction and hands-on activity, rather than pure discovery: "In many ways, guided discovery appears to offer the best method for promoting constructivist learning."

Kirchner et al (2006) agree with the basic premise of constructivism, that learners construct knowledge, but are concerned with the instructional design recommendations of this theoretical framework. "The constructivist description of learning is accurate, but the instructional consequences suggested by constructivists do not necessarily follow." (Kirschner, Sweller, and Clark, 2006, p. 78). Specifically, they say instructors often design unguided instruction that that relies on the learner to "discover or construct essential information for themselves" (Kirchner et al, 2006, p75).

For this reason they state that it "is easy to agree with Mayer's (2004) recommendation that we "move educational reform efforts from the fuzzy and nonproductive world of ideology—which sometimes hides under the various banners of constructivism—to the sharp and productive world of theory- based research on how people learn" (p. 18). Finally Kirschner, Sweller, and Clark (2006) cite Mayer to conclude fifty years of empirical results do not support unguided instruction.

Tasks (assignments)



Try to tell us about your understanding of constructivism as an approach in science education.

Which studying principles of constructivism are the most important according to you?
Whose scientists' ideas are related to the development of constructivist theory?
How is the new role of the teacher in constructivist education expressed?
What is your understanding of 'constructivist classroom"?

Case study

In class students discuss their understanding of constructivist theory. They compare traditional education to the one subdued to constructivism. They give examples related to physics education.

Questions to Case Study

Point out the new role of the teacher in constructivist education as compared to the traditional one.
Compare the constructivist classroom to the traditional one.

Summary

During the last years constructivism as an approach in education has had a central position in didactical literature. Constructivist theory is definitely accepted as a modern and leading theory in the teaching of science. Constructivism has become the most valuable guiding principle for the teachers of science, as well as for researchers in this field. Constructivist teaching fosters critical thinking and creates active and motivated learners. The constructivist theory has been incorporated into the curriculum, and advocates that teachers create environments in which children can construct their own understandings. There are different types of constructivism: cognitive, social, radical. The following principles of constructivism are important: active construction on the basis of the already exciting conceptions; arrangement of tentative constructor; checking its viability; acceptance of the social character of the construct. Constructivism changes the role of the teacher in the educational process and suggests a new model of teaching environmental.

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Frequently Asked Questions

Next Reading

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Unit 3

BUILDING AND DEVELOPING PROCESS SCIENCE SKILLS

Chapter Objectives: Following their work on the topic prospective teachers should:

- **improve their understanding of science concepts;**
- **define process scientific skills;**
- **classify process scientific skills (basic, integrated, related to students' age characteristics)**
- **describe the corresponding activities related to PSS**
- **describe Competency Indicators related to PSS**
- **know their place and importance within the State Educational Standards, school curriculum and the teaching of physics;**
- **characterize, explain, give examples and demonstrate strategies for supporting process skills development.**
- **Use efectivly varied teaching strategies to implement develpoing of procedural skills as to get information from the graph; develop in their students skills in processing of experimental data from table into graph form, in work with texts and in arranging presentations**.

What are process skills?

According to the English qualification Skills Qualifications are offered in six areas.

- **Communication:** speaking, listening, reading and writing skills
- **Application of Number:** interpreting information involving numbers, carrying out calculations, interpreting results and presenting findings
- **Information Communication Technology:** finding, exploring, developing and presenting information including text, images and numbers
- **Working with others:** includes process and interpersonal skills to support working cooperatively with others to achieve shared objectives, work cooperatively and have regard for others

1. **Improving own learning and performance:** developing independent learners who are clearly focused on what they want to achieve and able to work towards targets that will improve the quality of their learning and performance. The standards include process skills, e.g., target-setting, planning, learning, reviewing and interpersonal skills, e.g., communicating own needs, accepting constructive feedback, negotiating learning opportunities and support

- **Problem solving:** encouraging learners to develop and demonstrate their ability to tackle problems systematically, for the purpose of working towards their solution and learning from this process. Three types or combinations of problems are dealt with: diagnostic problems that depend primarily on analysis to arrive at conclusions, design problems that depend mainly on synthesis to create a product or process, and contingency problems that typically involve resource planning and gaining the cooperation of others, eg when organizing an event

The first three Skills are sometimes referred to as the 'main' Key Skills. They incorporate the basic skills of literacy and numeracy. The remaining three Key Skills are often referred to as the 'wider' or 'soft' Skills.

BASIC PROCESS SKILLS

Observation
includes using one or more of the senses to determine attributes, properties, similarities, differences and changes in natural phenomena and objects. Observation can be made directly with the senses or indirectly through the use of simple or complex instruments.

Classification
includes organizing objects or events according to similarities and differences selected by the observer. Classification includes sorting elements into groups on the basis of common characteristics and ordering (sequencing) elements by relationships among the elements.

Communication
includes the presentation and explanation of experiences with objects or events by means of oral or written descriptions, pictures, graphs, charts, maps, demonstration and/or other methods.

Measurement
includes the comparison of an unknown quantity e.g., length, mass, or temperature with a known quantity such as a pupil-made standard or the metric standards of length, area, volume, mass, temperature, force, time or electrical charge. Measurement includes the ability to estimate or compare an object or event with a frame of reference. Measurement involves the skillful, effective use of instruments.

Prediction
includes suggesting what will occur in the future based on observations, measurements and inferences about the relationships between or among observed variable. Predictions may be used to generalize that under a certain set of circumstances a certain outcome may be expected, or they may be used to describe outcomes beyond the observed data. The accuracy of a prediction is closely related to the accuracy of the observations.

Inference
includes the use of observations and past experiences to reach a conclusion about a probable cause or about future outcomes. Inferring from a set of data may lead to several nonconclusive inferences. Only further investigations and additional data may validate an inference.

Higher Level Process Skills

Identification
of variables includes finding the variables of a system and selecting those that are to be held constant.

Manipulation
of variables includes the identification of trends or patterns in sets of data. Patterns in the data may be used to establish generalizations, make predictions and formulate hypotheses. Interpreting data involves organizing, analyzing, synthesizing and evaluating patterns in data.

Interpretation
of data includes the identification of trends or patterns in sets of data. Patterns in the data may be used to establish generalizations, make predictions and formulate hypotheses. Interpreting data involves organizing, analyzing, synthesizing and evaluating patterns in the data.

Operational definition
includes defining objects in the context of a common experience, telling one what to do to or with an object and what to observe as a result of the action.

Formulation of models
includes describing or constructing physical, verbal, mental or mathematical explanations of systems and interrelated phenomena that cannot be observed directly. Models may be used in predicting outcomes of planned investigations.

Experimentation
includes the design and implementation of procedures to obtain reliable information about interrelationships between objects and events. Investigating includes formulating and solving a problem and experimenting and drawing conclusions.

Construction of hypotheses
includes formulating generalizations that include all objects or events of the same class. Questions, inferences and predictions can lead to the formation of a hypothesis. The hypothesis must be tested if its credibility is to be established.

Drawing Conclusions
includes interpreting data acquired through experimentation to determine if a hypothesis is supported.

What are scientific process skills?

Science and teaching students about science means more than scientific knowledge. There are three dimensions of science that are all important. The first of these is the content of science, the basic concepts, and our scientific knowledge. This is the dimension of science that most people first think about, and it is certainly very important.The other two important dimensions of science in addition to science knowledge are processes of doing science and scientific attitudes. The processes of doing science are the science process skills that scientists use in the process of doing science. Since science is about asking questions and finding answers to questions, these are actually the same skills that we all use in our daily lives as we try to figure out everyday questions. When we teach students to use these skills in science, we are also teaching them skills that they will use in the future in every area of their lives. The third dimension of science focuses on the characteristic attitudes and dispositions of science. These include such things as being curious and imaginative, as well as being enthusiastic about asking questions and solving problems. Another desirable scientific attitude is a respect for the methods and values of science. These scientific methods and values include seeking to answer questions using some kind of evidence, recognizing the importance of rechecking data, and understanding that scientific knowledge and theories change over time as more information is gathered.

SIX BASIC PROCESS SKILLS

The science process skills form the foundation for scientific methods. There are six basic science process skills:

- Observation
- Communication
- Classification
- Measurement
- Inference
- Prediction

These basic skills are integrated together when scientists design and carry out experiments or in everyday life when we all carry out *fair test* experiments. All the six basic skills are important individually as well as when they are integrated together.

SCIENCE PROCESS SKILLS

The event consists of a series of biological questions or tasks that involve the use of one or more process skills. Science process skills are classified as basic skills and integrated skills. These skills can be accessed by applying them to a series of lab station activities which are included in the Guide for Supervisors, Coaches and Students. Tips to assist students in their preparations are also included in this guide.

Basic Science Process Skills:

- **Observing** - using your senses to gather information about an object or event. It is a description of what was actually perceived. This information is considered qualitative data.
- **Measuring** - using standard measures or estimations to describe specific dimensions of an object or event. This information is considered quantitative data.
- **Inferring** - formulating assumptions or possible explanations based upon observations.
- **Classifying** - grouping or ordering objects or events into categories based upon characteristics or defined criteria.
- **Predicting** - guessing the most likely outcome of a future event based upon a pattern of evidence.
- **Communicating** - using words, symbols, or graphics to describe an object, action or event.

INTEGRATED SCIENCE PROCESS SKILLS:

• Formulating Hypotheses - stating the proposed solutions or expected outcomes for experiments. These proposed solutions to a problem must be testable.

• Identifying of Variables - stating the changeable factors that can affect an experiment. It is important to change only the variable being tested and keep the rest constant. The one being manipulated is the independent variable; the one being measured to determine its response is the dependent variable; and all variables that do not change and may be potential independent variables are constants.

• Defining Variables Operationally - explaining how to measure a variable in an experiment.

• Describing Relationships Between Variables - explain relationships between variables in an experiment such as between the independent and dependant variables plus the standard of comparison.

• Designing Investigations - designing an experiment by identifying materials and describing appropriate steps in a procedure to test a hypothesis.

• Experimenting - carrying out an experiment by carefully following directions of the procedure so the results can be verified by repeating the procedure several times.

• Acquiring Data - collecting qualitative and quantitative data as observations and measurements.

• Organizing Data in Tables and Graphs - making data tables and graphs for data collected.

• Analyzing Investigations and Their Data - interpreting data statistically, identifying human mistakes and experimental errors, evaluating the hypothesis, formulating conclusions, and recommending further testing where necessary.

• Understanding Cause and Effect Relationships - what caused what to happen and why.

• Formulating Models - recognizing patterns in data and making comparisons to familiar objects or ideas.

Basic Science Process Skills:

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• **Measuring -** using standard measures or estimations to describe specific dimensions of an object or event. This information is considered quantitative data.

• **Inferring -** formulating assumptions or possible explanations based upon observations.

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<u>Integrated Science Process Skills</u>:

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• **Understanding Cause and Effect Relationships** - what caused what to happen and why.

• **Formulating Models** - recognizing patterns in data and making

The importance of PSS

PSS is considered in preparing educational documents and when regarding it as a starting point in their explanation and practical application.

Knowledge of PSS provides teachers with the possibility to arrange their work straightforwardly in teaching new lessons and in the arrangement of different types of lessons and evaluation of students' knowledge.

Tasks (assignments)

- What is PS? What is PSS?
- List Basic PSS и Integrate PSS
- Why do you think future teachers need to know the PSS theory

Case study

In class students discuss their understanding of constructivist theory. Students work with the State educational requirements on the contents of physics and find PSS in them. They discuss the activities that could assist the formation of PSS. Each student prepares a lesson plan in which describes in details the PSS he intends to develop and the ways in which he will do it. Students swap plans and discuss them.

Questions to Case Study

- Do you think that your classmate has stated the PSS correctly for the topic given and has planned them thoroughly?
- Do you remember what PSS were developed in you when you were students? How did your teacher do that?

Summary

Science and teaching students about science means more than scientific knowledge. There are three dimensions of science that are all important. The first of these is the content of science, the basic concepts, and our scientific knowledge The other two important dimensions of science in addition to science knowledge are processes of doing science and scientific attitudes. The processes of doing science are the science process skills that scientists use in the process of doing science.There are different classification of the process skills: basic process skills (observing, measuring, inferring, classifying, predicting, communicating), integrated process skills and s.o.

Frequently Asked Questions

Next Reading

http://arapaho.nsuok.edu/~adams001/ProcessSkills.htm - Science Process Skills

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Unit 4

STRATEGIES FOR SUPPORTING PROCESS SKILLS DEVELOPMENT AND ASSESSMENT

Chapter Objectives:

Following their training in this topic students will:

- **Define teaching strategy, teaching method and teaching technique.**
- **Know diverse range of active teaching strategies;**
- **Be able to recognize different strategies for teaching and studying and distinguish between major teaching methods ;**
- **Be able to choose the appropriate strategy for process skills.**

Definition of teaching strategy;

The notion of strategy in didactics is sometimes used as a synonym of methods and techniques, and sometimes as a synonym of direction, activities and proceedings related to teaching, learning and the arrangement of the educational process. (Andreev)
Strategy is viewed as „an individual way to arrange and use a set of skills or techniques to the aim of a more rational assessment of definite information or one or another problem solving.“ Learning strategies are a combination of skills, a set of proceedings used by a learner according to the requirements of a definite situation. (Petrov, 2001) Strategy is any activity or attempt used by a teacher to interpret, illustrate or stimulate learning. For a more effective learning the teacher should seek for student centered and team work oriented strategies.
We can assume that strategies are a set of approaches, activities, methods and techniques used to stimulate learning and to help students assess the aims of education.

Teaching Method is a system for planning, carrying out, and evaluating a series of learning experiences. It includes development of objectives, ways and means of achieving objectives and procedures for evaluating learner progress. Method is also said to be a way of teaching, especially a regular, orderly, and definite procedure. Method is comprised of many techniques.
The following can be indicated as examples of teaching methods:

- Presentation /Sometimes known as subject matter teaching Teacher focused/.Examples:Demonstration,Lecture,Movie
- Conference procedure - Learner focused. Examples:Group discussion,Team activities,Role Playing.

Teaching Techniques are the details or procedure by which a method is carried out. Examples include: demonstrations, field trips, resource persons and the way something is used in teaching. **Teaching techniques are s**pecific approaches to teaching, manipulated by the teacher and designed to aid in helping students learn.

The following can be indicated as examples **of functions of Techniques**:

- Convey technical information;
- Promote student interest;
- Help students retain information;
- Make teaching more enjoyable;
- Involve the five senses.

Under t**eaching aids** could understand anything that aids teaching (pictures, charts, models, etc.(AV)) and objects which supplement and/or complement the learning environment.

Types of strategies for teaching and studying

Teaching and studying strategies can be classified as active, reproductive, research, analytic, checking, cognitive heuristic, reproductive and productive. The degree of independence and problem solving is used as criteria. For example, reproductive strategies include frontal teaching, asking questions, explanation, repetition, affirmation, independent work to solve cognitive tasks from the textbook**.**

Learning strategies are activities that make content and objectives become operative. This depends on selection strategies and techniques that make learning exciting and motivating. Carrying this out is the direct responsibility of the teachers and it is limited only by their own creativity.

Active teaching strategies are:

- Intellectually more stimulating and so are more effective in promoting learning;
- Likely to be enjoyed and therefore sustain pupil motivation;
- Offers opportunities for pupils to work and progress at their own speed;
- Offers opportunities for pupils to work collaboratively;
- Promote essential scientific skills such ass problem solving.

Teaching and learning strategies can be determined as from teacher-centered and to students-centered (Table).

Table 1

From Teacher-Centered	⟷	**To Student-Centered**
Objectives set by the teacher in advance to meet needs he had identified	Most of outcomes are predictable (set by teacher) but some outcomes will be unexpected. Pupils are made aware of the objectives in advance	Objectives are set by pupils, assisted by the teacher and will evolve during the learning process
All pupils go through the same learning experience at the same time	Pupils experience a variety of activities controlled by the teacher	Pupils will be engaged in variety of activities at any one time to suite their individual needs

Decisions are made by teachers who maintain control over the work and decide in advance the order in which things are taught	The teacher explains his decisions	Decisions are made by pupils or jointly by teachers and pupils, and pupils control the order in which they learn things
The teacher evaluates the success of his objectives	The teacher evaluates in terms of the extent to which pupils feel the teachers' objectives have been met	Pupils examine the process of their own learning and identify what they discovered and how
Relatively few teaching /learning methods are used. They are selected by teacher according to his preference or ideas	The teacher selects methods according to his perceptions of pupils' needs	Pupils and teachers select jointly from a wide variety of teaching/learning methods
The teacher is seen as a role, rather than as a person, relationships are formal	The teacher is seen as a person, but not as a member of the group	The teacher is seen as a person, not as a role. Personal relationships develop.
The teacher selects and provides resources and decides what is relevant	The teacher controls access to all resources	The teacher is seen as one of many resources to which pupils have access
The teacher is the ultimate authority and has 'the right answer'	The teacher manages the lesson in order to guide the pupils towards 'the right answer'	There may not be a 'right answer'. Everyone's opinion is valid.
The teacher instigates individual tasks which are performed in isolation	The teacher controls the degree of individual and group work	Communication and interpersonal skills are an essential part of the learning

A *strategy* is any activity or experience that the teacher uses to introduce, interpret, illustrate, and facilitate learning.

For a fostered effective learning to take place, the teacher should seek strategies that are student-centered and provide for group involvement. Additionally the teacher should use more than one strategy or activity for each major concept. In this way the instruction will encompass the variety of student abilities and aptitudes more fully. It is obvious that the choice of strategies is only one of the conditions influencing effective learning.

How to select affective strategies?

We should keep the following criteria in mind:

1. Any strategy selected should involve the students as participants in the activity, help them acquire knowledge, develop the ability to reason and asses the information presented.
2. Students learn in a variety of ways / remember three basic learning styles – auditory, visual, and kinesthetic/ and through different means. As a rule, more than two strategies or activities should be used particularly for more complex knowledge.
3. The teacher should begin with simpler and move to more complex strategies.

4. Audiovisual aids and visual tools should be included whenever possible for reinforce learning.
5. The ultimate factor to choose some or other strategies could indicate the following: abilities and interest of students, size of class, teacher competence, facilities available, time available, behavioral objectives of class, resources available.

ICT based strategies in the teaching of physics;

The study of pedagogic literature [1, 2] showed that when we talk about the education possibilities of information society we mean the **Internet** and **multimedia technologies**. They, in turn, are related to **hypertext, multimedia and hypermedia**, which means information of a qualitatively new type and places *new teaching strategies in physics education*. They can be related to the following aspects concerning certain strategies elements**:**

- The process of aims identification changes. The aims of a lesson with the use of multimedia should be multi-variant, on different levels, so that each student is able to find his place in it. The aims of teaching need new formulation and new order focused on the individual independent acquisition of knowledge;
- The choice of contents in multimedia and hypermedia has specific features. It is related to the correct amount and adaptation of information regarding the aims and should be systematized in its structure and systematically renewed;
- The very character of education changes and becomes highly individualized. Students' independent work needs new arrangement, which arises a necessity to research into the issues of the individual way to knowledge and the development of skills in independent study;
- Teachers are responsible for the creation of conditions and necessary instruments for self-control and self-evaluation of the expected results;
- With the mass access to ICT teachers' creativity becomes the main index of professional competency;

All in all the main functions of science teachers' change and a new teacher's professional profile is created. Teachers *become organizers, consultants, counselors and assistant*s and teaching becomes student centred to a significant degree.

To be able to use amply their creative possibilities in the use of multimedia in the teaching of physics, science teachers need to know what multimedia education possibilities are. The latter could be described in regard to several criteria, such as students' attitude, teaching arrangement and technical possibilities [4].

The use of multimedia in the teaching of physics has the following possibilities:

A/ In regard to students' development:

- Increases motivation;
- Activates students' participation in education, both in class and in their individual studies;
- Enhances interest in physics and astronomy;
- Increases the scientific level of presentation of knowledge;
- Widens students' knowledge about contemporary means of information;
- Provides additional possibilities for the development of model images;

B/ In regard to the arrangement of teaching:

- Creates possibilities for individualization and differentiation of teaching;
- Provides additional possibilities for problem situations;
- Provides good knowledge systematization;
- Arranges a fast check of hypothesis suggested to students;
- Makes possible a fast diagnosis of teaching results and a quality test check (highly objective evaluation, use of various problems, fast check);
- Provides possibilities for self-control;
- Use of graph and text designs for the results of assignments, didactic materials, presentations and papers;
- Use in laboratory and demonstration experiments;

C/ In regard to technical possibilities:

- Provides possibilities to include in the teaching of physics modeling processes impossible or difficult to demonstrate in reality;
- Provides additional visualization possibilities;
- Provides possibilities to measure and visualize fast processes;
- Provides possibilities to observe in details particular moments from a physics demonstration experiment;
- Provides possibilities for a successful representation of the transition from qualitative into quantitative research;
- Cuts down the time necessary for activities related to processing of information;
- Provides possibilities to present information in various ways (tables, graphs, drawings, etc.).

ICT use in the teaching of physics is not a "technological attraction, nor a universal panacea" [1]. The success of such teaching depends strongly on the degree in which teachers are able to motivate students and on teachers' skills to arrange correctly ICT use in the different types of physics lessons. In regard to this we offer some sample guidelines for ICT use which teachers can use in the preparation of their lessons and during different types of lessons in class.

Effective strategies for develpoing students' procedural skills as to get information from a graph, process experimental data from table into graph form, work with texts and arrange presentations.

GraphingData

Collection of data from a physics experiment and their graphic presentation is an important skill which students can develop through their learning of physics.

Graphs can be used to depict relationships between variables e.g., between independent and dependent variables. Patterns in the data are often more visible once the data has been plotted on a graph allowing the student to discern relationships and discrepancies in the data.

Prior to graphing data, teachers may want to take students through the stages of Data Collection. The process of collecting data on a set subject engages students in establishing relevant questions and collecting information/data to answer the question(s). Students should refine their methods, collect data, review the data, and repeat data collections to ensure quality of documentation. Students develop the ability to think critically about cause/effect relationships and statements based on evidence

Techniques used by a teacher to develop skills in collecting data.

Upon a successfully carried experiment the data on the corresponding values are arranged in a graph. It is important to determine the number of columns so that it corresponds to the number of the values measured. After that the teacher, together with the students, should name each column with the name of the value and its corresponding measure unit. The choice of measure needs to be emphasized. Students are required to fill in the table and be careful as to the use of the measure. It is necessary to determine the type of graph to be used for the graphic representation of the data. The simplest is the line graph. The following consequence of steps has to be observed:

- to determine which value is an argument and which is a function;
- the argument is presented horizontally, the function vertically;
- the values are represented with their measures on both axes;
- the zero is fixed;
- the numbers from the table are presented on the graph;
- the dots are connected with a line

After creating the graph, futher ideas for interpretation of data can be obtained from the Data Analysis strategy.

- Data Analysis

  In data analysis, students will use data from a variety of sources to create, interpret and analyze graphs. This strategy may be the continuation of the **Data Collection** strategy.

Data and Line Graphs

The student will be able to:

- Define data, line graphs, titles, labels, scales, points, and lines.
- Identify the parts of a line graph.
- Analyze and evaluate information from a line graph.
- Apply line graph concepts to interpret data from line graphs.

Constructing Line Graphs

The student will be able to:

- Define range, horizontal scale, and vertical scale.
- Describe the procedure for constructing a line graph from a set of data.
- Apply the procedure for constructing a line graph.

Work with the text

Work with a physics text is an important procedural skill. Students who have this skill present good chances for a successful independent work and self-study. The reading of physics text has its peculiarities of which a teacher should be aware. Some of them have to do with the presence of many and various presentations of physics values, s well as with graph, table, scheme, drawing and picture footmarks. The presence of mathematics formula is the most characteristic feature of physics texts. The teacher should assist students in the building of specialized reading skills.

For example, it is very important to arrange readings of physics texts in class. This method is reproductive in itself – the teacher reads and shows how to interpret symbols, formula and graphs. This approach is suitable for younger grades. For older students it is more suitable to give instructions for reading. These instructions can include the following: questions to be answered upon reading the text; writing formula in students’ notebooks with a corresponding note; oral explanation of graphs, etc.

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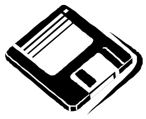
Arrange presentation

Developing presentation skills is useful for older students. It is the last stage of their independent work in finding and presenting of study materials. Presentation is based on students’ computer skills, their knowledge of presentation programs and their skills in independent systematization of study materials.



Tasks (assignments)

1. What is the relationship between strategy, method and technique? Define each notion.
2. Mention some strategies and methods of teaching. Explain one method of teaching of your choice.
3. Which are the criteria to choose a teaching strategy? Should the teacher use more than one strategy or activity in one lesson?
4. What requirements does ICT place to teachers? What didactic possibilities does ICT provide in the teaching of physics? What approaches do teachers of physics use when they use ICT in the different lesson types?
5. Describe possible strategies to form in students skills to get information from a graph.

Case study

1 Choose a text from the physics textbook and write instructions for students‘ independent work on it. Describe the method you shall use to evaluate the way students carried out the instructions.
2. Find bibliography on the criteria for quality presentation.

3. Describe the consequence of activities a student needs to follow to prepare a PP presentation.
4. Ask students to prepare a presentation /with no more than 5 slides/ on a topic of your choice as a homework assignment.

Questions to Case Study

– Why did you choose that text to use with students to develop their skills in work with texts? What methods did you use? Name the strategy you used.

– Have the student's activities in preparing the PP presentation been described in sufficient details?

– State ways to organize the evaluation of the PP presentations prepared by the students.

Summary

We assume that strategies are a set of approaches, activities, methods and techniques used to stimulate learning and to help students assess the aims of education.
Method is also said to be a way of teaching, especially a regular, orderly, and definite procedure. Method is comprised of many techniques. Teaching Techniques are the details or procedure by which a method is carried out. Teaching and studying strategies can be classified as active, reproductive, research, analytic, checking, cognitive heuristic, reproductive and productive. The degree of independence and problem solving is used as criteria. Some effective strategies for develpoing students' procedural skills as to get information from a graph, process experimental data from table into graph form, work with texts and arrange presentations have been considered.

Frequently Asked Questions

Next Reading

http://www.aea267.k12.ia.us/cia/index.php?page=teaching_strategies# - teaching strategies

http://www.ala.org/ala/aasl/aaslpubsandjournals/slmrb/slmrcontents/volume11998slmqo/carey.cfm#Top#Top - Library Skills, Information Skills, and Information Literacy: Implications for Teaching and Learning , James O. Carey, Assistant Professor, University of South Florida
file:///C:/Documents%20and%20Settings/admin/My%20Documents/Jane/AniEpitropova/Strategies%20for%20supporting/Teaching%20and%20Learning%20Methods%20and%20Strategies.htm - Teaching and Learning ,Methods and Strategies

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3. Епитропова А., Активни стратегии в обучението за природата и човека в 1-4 клас, „Макрос”, 2004
4. Elaine Wilson, Powerful pedagogical strategies in initial teacher education, Teacher and Teaching: theory and practice, Volume 11, Number 4, 2005
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Unit 5

PLAN, ORGANIZE AND DELIVER AN ACTIVE LEARNING PROJECT

Chapter Objectives:

Students will:

- **Be able to define AL;**
- **Know the characteristics of AL;**
- **Know the difficulties and hindrances of AL;**
- **Be able to name possible AL strategies;**
- **Know the peculiarities of certain AL strategies;**
- **Be able to use AL strategies to prepare their own project;**
- **Be able to use AL strategies in their work with students;**
- **Students will implement they knowledge and skills in lesson planing and perfoming.**

Definition of Active Learning;

"Active Learning" is, in short, anything that students do in a classroom other than merely passively listening to an instructor's lecture. This includes everything from listening practices which help the students to absorb what they hear, to short writing exercises in which students react to lecture material, to complex group exercises in which students apply course material to "real life" situations and/or to new problems

http://www.texascollaborative.org/activelearning.htm

Paulson & Faust, California State University, Los Angeles, http://www.calstatela.edu/dept/chem/chem2/Active/index.htm

Learning in an active search for meaning by the learner--constructive knowledge rather than passively receiving it, shaping as well as being shaped by experience....To stimulate an active search for meaning, faculty [must]:

- expect and demand student participation in activities in and beyond the classroom;
- design projects and endeavors through which students apply their knowledge and skills; and
- build programs that feature extended and increasingly challenging opportunities for growth and development. http://www.myacpa.org/pub/documents/taskforce.pdf

Active learning refers to techniques where students do more than simply listen to a lecture. Students are DOING something including discovering, processing, and applying information. Active learning "derives from two basic assumptions: (1) that learning is by nature an active endeavor and (2) that different people learn in different ways" (Meyers and Jones, 1993). Research shows greater learning when students engage in active learning. It is important to remember, however, that lecture does have its place and that you should not do active learning without content or objectives. The elements of active learning are talking and listening, writing, reading, and reflecting (Meyers and Jones, 1993).

Like many terms used to describe teaching or learning, active learning defies simple definitions. The following excerpts of definitions offer some insight into what others think active learning is. As an exercise in active learning, try looking critically at these phrases and the full text definitions that follow them.

Definition excerpts

- [students] use their brains...studying ideas, solving problems, and applying what they learn (1)
- Active learners energetically strive to take a greater responsibility for their own learning. (2)
- students...engage in the process of building their own mental models from the information they are acquiring...should constantly test the validity of the model being constructed (3)
- involves the student 'as his/her own teacher' (4)
- classroom strategies that get students more involved in the subject matter... social interaction and less competition...students working together(5)
- engaging one's self (the learner) with the material being learned... teacher teaches the student how to function and how to get the task done within the context of the discipline, the course, the class. It distributes the learning responsibility among the students and the teacher.(6)
- putting our students in situations which compel them to read, speak, listen, think deeply, and write.... puts the responsibility of organizing what is to be learned in the hands of the learners themselves(7)
- [students] must read, write, discuss, or be engaged in solving problems... students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation... instructional activities involving students in doing things and thinking about what they are doing (8)
- opportunities for learners to integrate new information, concepts, or skills into their own mental schema, through rephrasing, rehearsing, and practice (9)
- faculty become facilitators of learning, and students become active participants, engaging in a dialog with their colleagues and with the instructor (10)
- greater student engagement with critical thinking and 'higher levels' of learning...analysis, synthesis, and evaluation of information...in contrast to absorption (11)
- knowledge [is] directly experienced, constructed, acted upon, tested, or revised by the learner (12)

Full text definitions with citations

(1) Silberman, M. 1996 (Active Learning: 101 Strategies to Teach Any Subject) When learning is active, students do most of the work. They use their brains...studying ideas, solving problems, and applying what they learn. Active learning is fast-paced, fun, supportive, and personally engaging...To learn something well, it helps to hear it, see it, ask questions about it, and discuss it with others. Above all, students need to 'do it'--figure things out by themselves, come up with examples, try out skills, and do assignments that depend on the knowledge they already have or must acquire.

(2) Glasgow 1996 (Doing Science)

Active learners energetically strive to take a greater responsibility for their own learning. They take a more dynamic role in deciding how and what they need to know, what they should be able to do, and how they are going to do it. Their roles extend further into educational self-management, and self-motivation becomes a greater force behind learning.

(3) Modell and Michael 1993 (Promoting Active Learning in Life Science Classrooms)

We define an active learning environment as one in which students individually are encouraged to engage in the process of building their own mental models from the information they are acquiring. In addition, as part of the active learning process, the student should constantly test the validity of the model being constructed.

(4) UC Davis TAC Handbook:

Active learning is an approach to learning that involves the student 'as his/her own teacher.' Keep in mind that it is an approach, not a method

(5) http://www.iastate.edu/general/Inside/1996/1101/facForum.html Back to Excerpts

Finding classroom strategies that get students more involved in the subject matter -- that is, promoting 'active learning'--...

The notion of active learning has developed over the last dozen years or so, said Licklider, among cognitive psychologists who note that learning occurs best through social interaction and less competition. Active learning promotes a variety of methods, including students working together in and outside of class, as well as class lectures

(6) http://ublib.buffalo.edu/libraries/projects/tlr/active.html Back to Excerpts

Although the ultimate responsibility for learning rests with the students, good teaching encourages students to put forth more effort, gives opportunities for practice, and provides feedback on performance and freedom in learning. These characteristics are the essential elements of active learning. Active learning is engaging one's self (the learner) with the material being learned. In the classroom, the teacher teaches the student how to function and how to get the task done within the context of the discipline, the course, the class. It distributes the learning responsibility among the students and the teacher.

(7) http://edweb.sdsu.edu/people/bdodge/active/ActiveLearningk-12.html Back to Excerpts

Active learning isn't a new idea. It goes back at least as far as Socrates and was a major emphasis among progressive educators like John Dewey. And yet, if you peer into many classrooms, we seem to have forgotten that learning is naturally an active process. It involves putting our students in situations which compel them to read, speak, listen, think deeply, and write. While well delivered lectures are valuable and are not uncommon, sometimes the thinking required while attending a lecture is low level comprehension that goes from the ear to the writing hand and leaves the mind untouched. Active learning puts the responsibility of organizing what is to be learned in the hands of the learners themselves, and ideally lends itself to a more diverse range of learning styles.

(8) http://www.ntlf.com/html/lib/bib/91-9dig.htm Back to Excerpts

Surprisingly, educators' use of the term active learning has relied more on intuitive understanding than a common definition. Consequently, many faculty assert that all learning is inherently active and that students are therefore actively involved while listening to formal presentations in the classroom. Analysis of the research literature (Chickering and Gamson 1987), however, suggests that students must do more than just listen: They must read, write, discuss, or be engaged in solving problems. Most important, to be actively involved, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation. Within this context, it is proposed that strategies promoting active learning be defined as instructional activities involving students in doing things and thinking about what they are doing

(9) http://www.lib.utexas.edu/is/publications/active.html Back to Excerpts

First, a definition of active learning being used for this cookbook:

Library instruction activities that lead to active learning can last 5 minutes or several hours; the common goal is the provision of opportunities for learners to integrate new information, concepts, or skills into their own mental schema, through rephrasing, rehearsing, and practice. Activities can utilize group methods such as brainstorming, buzz groups or small group work. Individuals can experience active learning through paper and pencil exercises or individual seat work.

(10) http://www.uth.tmc.edu/apstracts/1996/advances/March/7s.html Back to Excerpts

Most students have spent the majority of their school career in passive learning environments in which faculty were disseminators of information, and students were required to memorize information or use specified algorithms to solve problems. In an active learning environment, students are encouraged to engage in the process of building and testing their own mental models from information that they are acquiring. In such a learner-centered environment, faculty become facilitators of learning, and students become active participants, engaging in a dialog with their colleagues and with the instructor.

(11) http://www.indiana.edu/~ict/grants_description.htm Back to Excerpts

Examples of active learning methods include, but are not limited to, collaborative learning, problem-based learning, case methods, course projects, simulations, and technology uses. Grants are intended to encourage greater student engagement with critical thinking and higher levels of learning … analysis, synthesis, and evaluation of information … in contrast to absorption

(12) http://www.che.ufl.edu/SUCCEED/pubs/innovator/innovator.1.2/succeed3.html Back to Excerpts

In active learning, knowledge [is] directly experienced, constructed, acted upon, tested, or revised by the learner.

Importance of Active Learning ;

- Research has shown that active learning is an exceptionally effective teaching technique.Regardless of the subject matter, when active learning is compared to traditional teaching methods (such as lecture), students learn more material, retain the information longer, and enjoy the class more. Active learning allows students to learn in the classroom with the help of the instructor and other students, rather than on their own.
- When students recognize that your course involves active learning, they will also recognize that they must be active if they are to succeed in the course.
- Active learning techniques are not educational magic bullets. Of course some of your students may not be willing to abandon their passive roles. But between those who are self-motivated and those who choose to sink, there is most likely a large middle group who, with some facilitating from you, will be active learners and markedly improve their performance and long-term command of the material.
- The obstacle to integrating active learning techniques into your class is contained within Confucius's aphorism: *I hear and I forget. I see and I remember. I do and I understand;*
- Content expertise ***and*** active teaching will provide students the opportunity to become engaged learners and dynamic thinkers.
- . They will analyze, synthesize, and evaluate information in discussion with other students, through asking questions, or through writing. In short, students will be engaged in activities that force them to reflect upon ideas and upon how they are using those ideas.

Characteristics of Active Learning;

Bonwell and Eison (1991) state that some characteristics of active learning are:

Students are involved in more than listening, less emphasis is placed on transmitting information and more on developing students' skills, students are involved in higher-order thinking (analysis, synthesis, evaluation), students are engaged in activities (e.g., reading discussing, writing), and greater emphasis is placed on students' exploration of their own attitudes and values.

Some active learning techniques take little faculty preparation and may be done spontaneously; others require much more preparation. Active learning techniques can occur in class or outside of class (e.g., computer simulations, internships, WWW assignments, class Internet discussion lists, independent study research). Active learning can be used with all levels of students from first year through graduate students. Teaching a mass class does not prohibit the use of active learning techniques; in fact, they may be especially important to promote interest and learning in a mass class. lhttp://www.teachtech.ilstu.edu/additional/tips/newActive.phpasses, and with all levels of students.- Kathleen McKinney, Cross Chair in the Scholarship of Teaching and Learning and Professor of Sociology,Illinois State University,Active Learning

Barriers to Active Learning

While the activities described here might seem appealing, they often seem appealing for other instructors or other disciplines–but not for our own. That is, a certain amount of internal resistance sometimes sets in. Trying new activities might seem like inviting disaster, especially when it means giving up the control that a lecturer commands. And there is always the pressure to cover more and more material, so that activities involving students–activities taking up classroom time–seem wasteful. There is also a kind of institutional pressure not to experiment with our teaching, since any experimentation takes thinking about–thereby taking time away from our research and writing. Incentives and even collegial support to improve or alter our teaching are often nonexistent. And also, of course, is the fear of trying something new and failing–a fear of taking risks in the classroom. Despite the fact that trying new teaching methods can feel uncomfortable, instructors who are using active learning in their large classes believe it makes a difference and is worth experimenting with. Without truly sacrificing breadth of coverage, we are able to increase depth of understanding, since students must engage with the material we're presenting and immediately attempt to use it, not just note it down for future thought. Getting your students involved in activities in the classroom also requires them regularly to assess their own degree of understanding and skill at handling concepts or problems in your discipline. Rather than allowing them to rest comfortably with a surface knowledge, it forces them to develop a deeper understanding. As a result, students are much more likely to study carefully, to regularly note their own questions or difficulties with assignments.

In their very helpful article "Navigating the Bumpy Road to Student-Centered Instruction," (http://www.ncsu.edu/felder-public/Papers/Resist.html) Richard M. Felder and Rebecca Brent explore the change from a lecture-based classroom to a more student-centered learning environment:

Teachers often state the following reasons for not using AY.The authors many of the common concerns about active learning, including:

- If I spend time in class on active learning exercises, I'll never get through the syllabus.
- If I don't lecture I'll lose control of the class.
- Some of my students just don't seem to get what I'm asking them to do-they keep trying to find "the right answer" to open-ended problems, they still don't have a clue about what a critical question is, and the problems they make up are consistently trivial.
- When I tried active learning in one of my classes, many of the students hated it. Some refused to cooperate and made their hostility to the approach and to me very clear.
- I'm having a particularly hard time getting my students to work in teams. Many of them resent having to do it and a couple of them protested to my department head about it.
- If I assign homework, presentation, or projects to groups, some students will "hitchhike," getting credit for work in which they did not actively participate.

- Many of the cooperative teams in my class are not working well-their assignments are superficial and incomplete and some team members keep complaining to me about others not participating.
- Teams working together on quantitative problem assignments may always rely on one or two members to get the problem solutions started. The others may then have difficulties on individual tests, when they must begin the solutions themselves.
- I teach a class containing students in minority populations that tend to be at risk academically. Does active, cooperative learning work in this kind of setting?
- Even though I've done everything the experts recommend, some of my students still complain that they don't like the student-centered approach I'm using and they would have learned more if they had taken a "normal" class.

Another highly recommended article is "Getting Students Involved in the Classroom," excerpted from Bergquist, W.H. & Phillips, S.R. (1975). *A Handbook for Faculty Development*. Council for the Advancement of Small Colleges, Washington, D.C. http://www.clt.cornell.edu/campus/teach/faculty/Materials/GettingStsInvolved.pdf The authors detail the more common causes for student non-involvement—instructors using one-way communication; students preferring involvement-avoidance learning styles; courses lacking specific structures that foster participation—and offer some possible solutions.

To address adequately why most faculty have not embraced recent calls for educational reform, it is necessary first to identify and understand common barriers to instructional change, including the powerful influence of educational tradition; faculty self-perceptions and self-definition of roles; the discomfort and anxiety that change creates; and the limited incentives for faculty to change.

But certain specific obstacles are associated with the use of active learning including limited class time; a possible increase in preparation time; the potential difficulty of using active learning in large classes; and a lack of needed materials, equipment, or resources.

Perhaps the single greatest barrier of all, however, is the fact that faculty members' efforts to employ active learning involve risk--the risks that students will not participate, use higher-order thinking, or learn sufficient content, that faculty members will feel a loss of control, lack necessary skills, or be criticized for teaching in unorthodox ways. Each obstacle or barrier and type of risk, however, can be successfully overcome through careful, thoughtful planning.

Active Learning strategies and methods

TECHNIQUES OF ACTIVE LEARNING

Exercises for Individual Students

Because these techniques are aimed at individual students, they can very easily be used without interrupting the flow of the class. These exercises are particularly useful in providing the instructor with feedback concerning student understanding and retention of material. Some (numbers 3 and 4, in particular) are especially designed to encourage students' exploration of their own attitudes and values. Many (especially numbers 4 - 6) are designed to increase retention of material presented in lectures and texts.

1. **The "One Minute Paper"** - This is a highly effective technique for checking student progress, both in understanding the material and in reacting to course material. Ask students to take out a blank sheet of paper, pose a question (either specific or open-ended), and give them one (or perhaps two - but not many more) minute(s) to respond.
2. **Muddiest (or Clearest) Point** - This is a variation on the one-minute paper, though you may wish to give students a slightly longer time period to answer the question. Here you ask (at the end of a class period, or at a natural break in the presentation).
3. **Affective Response** - Again, this is similar to the above exercises, but here you are asking students to report their reactions to some facet of the course material - i.e., to provide an emotional or valuative response to the material. Obviously, this approach is limited to those subject areas in which such questions are appropriate (one should not, for instance, inquire into students' affective responses to vertebrate taxonomy). However, it can be quite a useful starting point for courses such as applied ethics, particularly as a precursor to theoretical analysis. For example, you might ask students what they think of Dr. Jack Kevorkian's activities, before presenting what various moral theorists would make of them. By having several views "on the table" before theory is presented, you can help students to see the material in context and to explore their own beliefs. It is also a good way to begin a discussion of evolutionary theory or any other scientific area where the general public often has views contrary to current scientific thinking, such as paper vs. plastic packaging or nuclear power generation.

4. **Daily Journal** - This combines the advantages of the above three techniques, and allows for more in-depth discussion of or reaction to course material. You may set aside class time for students to complete their journal entries, or assign this as homework. The only disadvantage to this approach is that the feedback will not be as "instant" as with the one-minute paper (and other assignments which you collect the day of the relevant lecture). But with this approach (particularly if entries are assigned for homework), you may ask more complex questions, such as, "Do you think that determinism is correct, or that humans have free will? Explain your answer.", or "Do you think that Dr. Kevorkian's actions are morally right? What would John Stuart Mill say?" and so on. Or you might have students find and discuss reports of scientific studies in popular media on topics relevant to course material, such as global warming, the ozone layer, and so forth.

5. **Reading Quiz** - Clearly, this is one way to coerce students to read assigned material! Active learning depends upon students coming to class prepared. The reading quiz can also be used as an effective measure of student comprehension of the readings (so that you may gauge their level of sophistication as readers). Further, by asking the same sorts of questions on several reading quizzes, you will give students guidance as to what to look for when reading assigned text. If you ask questions like "What color were Esmerelda's eyes?" (as my high school literature teacher liked to do), you are telling the student that it is the details that count, whereas questions like "What reason did Esmerelda give, for murdering Sebastian?" highlight issues of justification. If your goal is to instruct (and not merely to coerce), carefully choose questions which will both identify who has read the material (for your sake) and identify what is important

in the reading (for their sake).

6. **Clarification Pauses** - This is a simple technique aimed at fostering "active listening". Throughout a lecture, particularly after stating an important point or defining a key concept, stop, let it sink in, and then (after waiting a bit!) ask if anyone needs to have it clarified. You can also circulate around the room during these pauses to look at student notes, answer questions, etc. Students who would never ask a question in front of the whole class will ask questions during a clarification pause as you move about the room.

7. **Response to a demonstration or other teacher centered activity** - The students are asked to write a paragraph that begins with: I was surprised that ... I learned that ... I wonder about ... This allows the students to reflect on what they actually got out of the teachers' presentation. It also helps students realize that the activity was designed for more than just entertainment.

Questions and Answers

While most of us use questions as a way of prodding students and instantly testing comprehension, there are simple ways of tweaking our questioning techniques which increase student involvement and comprehension. Though some of the techniques listed here are "obvious", we will proceed on the principle that the obvious sometimes bears repeating (a useful pedagogical principle, to be sure!).

The "Socratic Method"

Taking its namesake from the most famous gadfly in history, this technique in its original format involved instructors "testing" student knowledge (of reading assignments, lectures, or perhaps applications of course material to a wider context) by asking questions during the course of a lecture. Typically, the instructor chooses a particular student, presents her with a question, and expects an answer forthwith; if the "chosen" student cannot answer the question presented, the instructor chooses another (and another) until the desired answer is received. This method has come under criticism, based on claims that it singles out students (potentially embarrassing them), and/or that it favors only a small segment of the class (i.e., that small percentage of the class who can answer any question thrown at them). In addition, once a student has answered a question they may not pay much attention as it will be a long time before the teacher returns to them for a second question. In spite of these criticisms, we feel that the Socratic method is an important and useful one; the following techniques suggest variations which enhance this method, avoiding some of these pitfalls.

8. **Wait Time** - Rather than choosing the student who will answer the question presented, this variation has the instructor WAITING before calling on someone to

answer it. The wait time will generally be short (15 seconds or so) - but it may seem interminable in the classroom. It is important to insist that no one raise his hand (or shout out the answer) before you give the OK, in order to discourage the typical scenario in which the five students in the front row all immediately volunteer to answer the question, and everyone else sighs in relief. Waiting forces every student to think about the question, rather than passively relying on those students who are fastest out of the gate to answer every question. When the wait time is up, the instructor asks for volunteers or randomly picks a student to answer the question. Once students are in the habit of waiting after questions are asked, more will get involved in the process.

9. **Student Summary of Another Student's Answer** - In order to promote active listening, after one student has volunteered an answer to your question, ask another student to summarize the first student's response. Many students hear little of what their classmates have to say, waiting instead for the instructor to either correct or repeat the answer. Having students summarize or repeat each others' contributions to the course both fosters active participation by all students and promotes the idea that learning is a shared enterprise. Given the possibility of being asked to repeat a classmates' comments, most students will listen more attentively to each other.

10. **The Fish Bowl** - Students are given index cards, and asked to write down one question concerning the course material. They should be directed to ask a question of clarification regarding some aspect of the material which they do not fully understand; or, perhaps you may allow questions concerning the application of course material to practical contexts. At the end of the class period (or, at the beginning of the next class meeting if the question is assigned for homework), students deposit their questions in a fish bowl. The instructor then draws several questions out of the bowl and answers them for the class or asks the class to answer them. This technique can be combined with others.

11. **Quiz/Test Questions** - Here students are asked to become actively involved in creating quizzes and tests by constructing some (or all) of the questions for the exams. This exercise may be assigned for homework and itself evaluated (perhaps for extra credit points). In asking students to think up exam questions, we encourage them to think more deeply about the course material and to explore major themes, comparison of views presented, applications, and other higher-order thinking skills. Once suggested questions are collected, the instructor may use them as the basis of review sessions, and/or to model the most effective questions. Further, you may ask students to discuss the merits of a sample of questions submitted; in discussing questions, they will significantly increase their engagement of the material to supply answers. Students might be asked to discuss several aspects of two different questions on the same material including degree of difficulty, effectiveness in assessing their learning, proper scope of questions, and so forth.

Immediate Feedback

These techniques are designed to give the instructor some indication of student understanding of the material presented during the lecture itself. These activities provide formative assessment rather than summative assessment of student understanding, Formative assessment is evaluation of the class as a whole in order to provide information for the benefit of the students and the instructor, but the information is not used as part of the course grade; summative assessment is any evaluation of student performance which becomes part of the course grade. For each feedback method, the instructor stops at appropriate points to give quick tests of the material; in this way, she can adjust the lecture mid-course, slowing down to spend more time on the concepts students are having difficulty with or moving more quickly to applications of concepts of which students have a good understanding.

12. **Finger Signals** - This method provides instructors with a means of testing student comprehension without the waiting period or the grading time required for written quizzes. Students are asked questions and instructed to signal their answers by holding up the appropriate number of fingers immediately in front of their torsos (this makes it impossible for students to "copy", thus committing them to answer each question on their own). For example, the instructor might say "one finger for 'yes', two for 'no'", and then ask questions such as "Do all organic compounds contain carbon [hydrogen, etc.]?". Or, the instructor might have multiple choice questions prepared for the overhead projector and have the answers numbered (1) through (5), asking students to answer with finger signals. In very large classes the students can use a set of large cardboard signs with numbers written on them. This method allows instructors to assess student knowledge literally at a glance.

13. **Flash Cards** - A variation of the Finger Signals approach, this method tests students' comprehension through their response to flash cards held by the instructor. This is particularly useful in disciplines which utilize models or other visual stimuli, such as chemistry, physics or biology. For example, the instructor might flash the diagram of a chemical compound and ask "Does this compound react with H_2O?". This can be combined with finger signals.

14. **Quotations** - This is a particularly useful method of testing student understanding when they are learning to read texts and identify an author's viewpoint and arguments. After students have read a representative advocate of each of several opposing theories or schools of thought, and the relevant concepts have been defined and discussed in class, put on the overhead projector a quotation by an author whom they have not read in the assigned materials, and ask them to figure out what position that person advocates. In addition to testing comprehension of the material presented in lecture, this exercise develops critical thinking and analysis skills. This would be very useful, for example, in discussing the various aspects of evolutionary theory.

Critical Thinking Motivators

Sometimes it is helpful to get students involved in discussion of or thinking about course material either before any theory is presented in lecture or after several conflicting theories have been presented. The idea in the first case is to generate data or questions prior to mapping out the theoretical landscape; in the second case, the students learn to assess the relative merits of several approaches.

15. **The Pre-Theoretic Intuitions Quiz** - Students often dutifully record everything the instructor says during a lecture and then ask at the end of the day or the course "what use is any of this?", or "what good will philosophy [organic chemistry, etc.] do for us?". To avoid such questions, and to get students interested in a topic before lectures begin, an instructor can give a quiz aimed at getting students to both identify and to assess their own views. An example of this is a long "True or False" questionnaire designed to start students thinking about moral theory (to be administered on the first or second day of an introductory ethics course), which includes statements such as "There are really no correct answers to moral questions" and "Whatever a society holds to be morally right is in fact morally right". After students have responded to the questions individually, have them compare answers in pairs or small groups and discuss the ones on which they disagree. This technique may also be used to assess student knowledge of the subject matter in a pre-/post-lecture comparison. The well-known "Force Concept Inventory" developed by Hestenes to measure understanding of force and motion is another good example of this.

16. **Puzzles/Paradoxes** - One of the most useful means of ferreting out students' intuitions on a given topic is to present them with a paradox or a puzzle involving the concept(s) at issue, and to have them struggle towards a solution. By forcing the students to "work it out" without some authority's solution, you increase the likelihood that they will be able to critically assess theories when they are presented later. For example, students in a course on theories of truth might be asked to assess the infamous "Liar Paradox" (with instances such as 'This sentence is false'), and to suggest ways in which such paradoxes can be avoided. Introductory logic students might be presented with complex logic puzzles as a way of motivating truth tables, and so forth. In scientific fields you can present experimental data which seems to contradict parts of the theory just presented or use examples which seem to have features which support two opposing theories.

Share/Pair

Grouping students in pairs allows many of the advantages of group work students have the opportunity to state their own views, to hear from others, to hone their argumentative skills, and so forth without the administrative "costs" of group work (time spent assigning people to groups, class time used just for "getting in groups", and so on). Further, pairs make it virtually impossible for students to avoid participating thus making each person accountable.

17. **Discussion** - Students are asked to pair off and to respond to a question either in turn or as a pair. This can easily be combined with other techniques such as those under "Questions and Answers" or "Critical Thinking Motivators" above. For example, after students have responded to statements, such as "Whatever a society holds to be morally right is in fact morally right" with 'true' or 'false', they can be asked to compare answers to a limited number of questions and to discuss the statements on which they differed. In science classes students can be asked to explain some experimental data that supports a theory just discussed by the lecturer. Generally, this

works best when students are given explicit directions, such as "Tell each other why you chose the answer you did".

18. **Note Comparison/Sharing** - One reason that some students perform poorly in classes is that they often do not have good note-taking skills. That is, while they might listen attentively, students do not always know what to write down, or they may have gaps in their notes which will leave them bewildered when they go back to the notes to study or to write a paper. One way to avoid some of these pitfalls and to have students model good note-taking is to have them occasionally compare notes. The instructor might stop lecturing immediately after covering a crucial concept and have students read each others' notes, filling in the gaps in their own note-taking. This is especially useful in introductory courses or in courses designed for non-majors or special admissions students. Once students see the value of supplementing their own note-taking with others', they are likely to continue the practice outside of class time.

19. **Evaluation of Another Student's Work** - Students are asked to complete an individual homework assignment or short paper. On the day the assignment is due, students submit one copy to the instructor to be graded and one copy to their partner. These may be assigned that day, or students may be assigned partners to work with throughout the term. Each student then takes their partner's work and depending on the nature of the assignment gives critical feedback, standardizes or assesses the arguments, corrects mistakes in problem-solving or grammar, and so forth. This is a particularly effective way to improve student writing.

Cooperative Learning Exercises

For more complex projects, where many heads are better than one or two, you may want to have students work in groups of three or more. As the term "cooperative learning" suggests, students working in groups will help each other to learn. Generally, it is better to form heterogeneous groups (with regard to gender, ethnicity, and academic performance), particularly when the groups will be working together over time or on complex projects; however, some of these techniques work well with spontaneously formed groups. Cooperative groups encourage discussion of problem solving techniques ("Should we try this?", etc.), and avoid the embarrassment of students who have not yet mastered all of the skills required.

20. **Cooperative Groups in Class -** Pose a question to be worked on in each cooperative group and then circulate around the room answering questions, asking further questions, keeping the groups on task, and so forth.. After an appropriate time for group discussion, students are asked to share their discussion points with the rest of the class. (The ensuing discussion can be guided according to the "Questions and Answers" techniques outlined above.)

21. **Active Review Sessions** - In the traditional class review session the students ask questions and the instructor answers them. Students spend their time copying down answers rather than thinking about the material. In an active review session the instructor posses questions and the students work on them in groups. Then students are

asked to show their solutions to the whole group and discuss any differences among solutions proposed.

22. **Work at the Blackboard** - In many problem solving courses (e.g., logic or critical thinking), instructors tend to review homework or teach problem solving techniques by solving the problems themselves. Because students learn more by doing, rather than watching, this is probably not the optimal scenario. Rather than illustrating problem solving, have students work out the problems themselves, by asking them to go to the blackboard in small groups to solve problems. If there is insufficient blackboard space, students can still work out problems as a group, using paper and pencil or computers if appropriate software is available.

23. **Concept Mapping** - A concept map is a way of illustrating the connections that exist between terms or concepts covered in course material; students construct concept maps by connecting individual terms by lines which indicate the relationship between each set of connected terms. Most of the terms in a concept map have multiple connections. Developing a concept map requires the students to identify and organize information and to establish meaningful relationships between the pieces of information.

24. **Visual Lists** - Here students are asked to make a list--on paper or on the blackboard; by working in groups, students typically can generate more comprehensive lists than they might if working alone. This method is particularly effective when students are asked to compare views or to list pros and cons of a position. One technique which works well with such comparisons is to have students draw a "T" and to label the left- and right-hand sides of the cross bar with the opposing positions (or 'Pro' and 'Con'). They then list everything they can think of which supports these positions on the relevant side of the vertical line. Once they have generated as thorough a list as they can, ask them to analyze the lists with questions appropriate to the exercise. For example, when discussing Utilitarianism (a theory which claims that an action is morally right whenever it results in more benefits than harms) students can use the "T" method to list all of the (potential) benefits and harms of an action, and then discuss which side is more heavily "weighted". Often having the list before them helps to determine the ultimate utility of the action, and the requirement to fill in the "T" generally results in a more thorough accounting of the consequences of the action in question. In science classes this would work well with such topics as massive vaccination programs, nuclear power, eliminating chlorofluorocarbons, reducing carbon dioxide emissions, and so forth.

25. **Jigsaw Group Projects** - In jigsaw projects, each member of a group is asked to complete some discrete part of an assignment; when every member has completed his assigned task, the pieces can be joined together to form a finished project. For example, students in a course in African geography might be grouped and each assigned a country; individual students in the group could then be assigned to research the economy, political structure, ethnic makeup, terrain and climate, or folklore of the assigned country. When each student has completed his research, the group then reforms to complete a comprehensive report. In a chemistry course each student group could research a different form of power generation (nuclear, fossil fuel, hydroelectric, etc.). Then the groups are reformed so that each group has an expert in one form of power generation. They then tackle the difficult problem of how much emphasis

should be placed on each method.

26. **Role Playing** - Here students are asked to "act out" a part. In doing so, they get a better idea of the concepts and theories being discussed. Role-playing exercises can range from the simple (e.g., "What would you do if a Nazi came to your door, and you were hiding a Jewish family in the attic?") to the complex. Complex role playing might take the form of a play (depending on time and resources); for example, students studying ancient philosophy might be asked to recreate the trial of Socrates. Using various sources (e.g., Plato's dialogues, Stone's The Trial of Socrates, and Aristophanes' The Clouds), student teams can prepare the prosecution and defense of Socrates on the charges of corruption of youth and treason; each team may present witnesses (limited to characters which appear in the Dialogues, for instance) to construct their case, and prepare questions for cross-examination.

27. **Panel Discussions** - Panel discussions are especially useful when students are asked to give class presentations or reports as a way of including the entire class in the presentation. Student groups are assigned a topic to research and asked to prepare presentations (note that this may readily be combined with the jigsaw method outlined above). Each panelist is then expected to make a very short presentation, before the floor is opened to questions from "the audience". The key to success is to choose topics carefully and to give students sufficient direction to ensure that they are well-prepared for their presentations. You might also want to prepare the "audience", by assigning them various roles. For example, if students are presenting the results of their research into several forms of energy, you might have some of the other students role play as concerned environmentalists, transportation officials, commuters, and so forth.

28. **Debates** - Actually a variation of N27, formal debates provide an efficient structure for class presentations when the subject matter easily divides into opposing views or ‘Pro’/‘Con’ considerations. Students are assigned to debate teams, given a position to defend, and then asked to present arguments in support of their position on the presentation day. The opposing team should be given an opportunity to rebut the argument(s) and, time permitting, the original presenters asked to respond to the rebuttal. This format is particularly useful in developing argumentation skills (in addition to teaching content).

29. **Games** - Many will scoff at the idea that one would literally play games in a university setting, but occasionally there is no better instructional tool. In particular, there are some concepts or theories which are more easily illustrated than discussed and in these cases, a well-conceived game may convey the idea more readily. For example, when students are introduced to the concepts of "laws of nature" and "the scientific method", it is hard to convey through lectures the nature of scientific work and the fallibility of inductive hypotheses. Instead, students play a couple rounds of the Induction Game, in which playing cards are turned up and either added to a running series or discarded according to the dealer’s pre-conceived "law of nature". Students are asked to "discover" the natural law, by formulating and testing hypotheses as the game proceeds.

Tasks (assignments)

What are some common themes in the definitions?

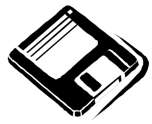
How do the definitions differ from each other?

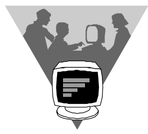
Which definitions most closely resemble your prior conceptions of active learning?

In your view, what determines the significance of the use of AY as a pedagogic approach? Why would you choose to use it?

Which of the AY hindrances listed are most common and most reasonable?

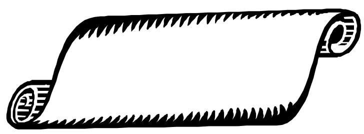
Give an example related to physics curriculum for each listed technique/method of AY arrangement.





Case study

Prepare a physics lesson scenario with the use of Active Learning and a strategy of your choice.
Here is a plan of a lesson. Write instructions for a part of the lesson: „Transformer“ in the form of Active Learning.



Questions to Case Study

Compare a lesson scenario according to traditional methodology and such one according to the requierements of AY.

Summary

Various definitions of Active Learning have been pointed. The features of Active Learning have been listed and its importance in teaching has been emphasized. Some hindrances for Active Learning have been discussed and possible strategies have been listed.

Frequently Asked Questions

Next Reading

http://attf.iu.edu/about/finrpts/cooney.html

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