Chapter 1 : Developing Science Skills, Catherine Valentino

Learning and Assessing Science Process Skills is all you need to develop the knowledge and skills necessary to bring the science process skills to your students. Features: Big Science Ideas - in each chapter major science concepts, themes, and topics used for the process skills activities are identified.

All these six basic skills are important as separate entities and they are also important as connected to one another. They are necessary to students when the latter describe, conduct and estimate an experiment or in everyday life when they face the challenge to solve problems of experimental character. What types of activity each of these skills includes? 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. Observation is a description of what is actually perceived. Via observation information is gathered, and the latter is used for qualitative data about the tested objects and phenomena. 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. Measurement includes the comparison of an unknown quantity e. 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. Conclusion is the use of data from the observation and measurement in order a definite deduction to be reached, and it should be related to probable causes or future results. Drawing a conclusion as a result of collected data analysis is an important science skill. Even when the available data is not enough for drawing a conclusion, having such a skill provokes a resolution for continuance or discontinuance of future research for gathering additional data. It includes suggesting what will occur in the future based on observations, measurements and inferences about the relationships between or among observed variable. It is an answer to the question: We can make the following list of integrated process science skills: Formulating Hypotheses â€" stating the proposed solutions or expected outcomes for experiments. These proposed solutions to a problem must be testable. This skill is connected 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. Describing Relationships Between Variables. It refers to explain relationships between variables in an experiment such as between the independent and dependant variables plus the standard of comparison. It referes to designing an experiment by identifying materials and describing appropriate steps in a procedure to test a hypothesis. Carrying out an experiment by carefully following directions of the procedure so the results can be verified by repeating the procedure several times. 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 â€" 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. Recognizing patterns in data and making comparisons to familiar objects or ideas. Formation and development of process science skills Formation of the basic process science skills should be one of the objectives, which a physics teacher has since the preparation for the lessons and he or she should follow it conscientiously during the process of the lessons. Having knowledge of these skills is the first prerequisite for the teacher to look for opportunities in compliance with the curriculum in order to build up the skills in the students. Which are the ways these skills or part of them to be build up during physics classes? We will consider some requirements and peculiarities of the formation of basic process science skills. There is a certain overlap between some of them, but it is inevitable, because of the process skills complex character. Observation goes together with all demonstrational physics experiments. The formation of skills for active observation may start since elementary education degree and may be organized according to the following

requirements: Providing demonstrativeness to a sufficient extent. Demonstrativeness presupposes placing the experiment in the right spot, so that it could be seen by all students; choosing a suitable background and contrast of colors, adequately visible metrical scales, etc. It is recommended to use ICT or other audiovisuals if necessary. In advance, to the students attention a number of questions is presented, and students can answer these question during the observation itself. A purposeful observation skill is formed so. In cases when the observation is not direct, it is necessary to use a device or instrument; it is recommended the teacher to make the students acquainted with the given instrument, with the way it works, and the work safety, and the important and proper to students processing parameters. About measurement instruments, the metrical scale should be examined in advance, the relevant units of measurement and their multiples, too. This preparation teaches the student to be precise, that, many times, is vitally important to the accuracy of observation, and it builds up in them basic skills for organizing a focused observation and collecting needed qualitative data. Organizing an opportunity to draw parallels during the process of observation itself. Using the parallels method, if the phenomenon or the trial allows it, is a good technique for outlining and discerning the important features. Observation is finished when the questions asked in advance are answered and the students are given a description of the process, phenomenon or effect that is demonstrated or observed. Quality data collected via observation is used for determining the similarities and differences between the examined objects and phenomena or for their parallel to definite criteria. For example, to be determined that a certain phenomenon has an electrostatic character, or that the force of friction specifies certain effect, this is a demonstration of a classification skill. For this skill formation teachers should establish circumstances, in which the students describe the observation and teachers should also organize a seminar on the basic peculiarities of the observed phenomenon and object to be clearly seen. During measurement, a certain characteristic of the object or phenomenon is juxtaposed to a given standard of measures and its value is specified. Measuring includes juxtaposition of an unknown quantity length, mass, temperature, surface, capacity, mass, force, time, charge, etc. In physics teaching opportunities for realization of that are really many. On the first place the quantity needs to be specified, its units of measurement should be remembered â€" which of these units are part of the SI system and which ones are out of any system; Making the students acquainted with the measurement instrument is the second step, the students should be informed about the functions of the instrument, which quantities it measures, when and how it works and is used; An important thing is getting acquainted with the metrical scale. Teachers should train students to work with metrical scales, and teachers should present the following sequence of actions: Reading a physics measurement instrument report is related to two important requirements: Drawing a conclusion is a complex mental activity which presupposes results analysis and forming a statement having causative-consecutive character. This seminar should focus their attention on finding the causes and their relation to the consequences. General recommendations about that are irrelevant, because the phases of analysis and synthesis strictly depend on the certain case. As a basic process science skill the prediction is a reflection of one of science main characteristics â€" to prognosticate phenomena and processes. Elements of this skill could be formed when students are in advance facing tricky matters, related to the final result of the observation. Enigmatizing and a guess-the final-result situation is a method which students find interesting. Knowing the physicals objective laws is a condition for the prediction skill to be build up in students. They should be able to foresee the result of a certain physical phenomenon or to explain it as they consider the final conditions of its course. The explanation is related to prediction and many times it is a preceding action. But prediction does not necessarily mean explanation of the phenomenon. Communication is a process skill for whose formation physics teaching process offers excellent opportunities. Expressing the information collected during the observation and measuring should be done in a proper manner. It could happen in the following ways: Wording and presenting results in written or oral form. Texts require a proper physics language. This is a problem of great importance which the physics teacher can solve through consistency and patience. Literature offers a description of different methods and approaches to formation of proper physics language [2]. The analytical way is a typical way for expressing physics objective laws-i. Since primary school students should know how to write, read, and, as a whole, to use this specific physics language. The relation between mathematics and physics has a great significance. A teacher should

not allow learning physics formulae by heart â€” without understanding of their meaning. About graphic skills formation physics teaching gives a vast number of opportunities. All physics branches, which are included in the curriculum, contain enough graphic material. The sequence of activities which helps this skill formation is presented in the next chapter. Tasks assignments What is process skill? What is process science skill? Make a list of process science skills. Give examples for formation of all basic process science skills with appropriate according to your opinion physics demonstrational experiment. Case study During case study students discuss their own understanding about process science skills. They discuss the activities that could assist the formation of process science skills. Each student prepares a lesson plan in which describes in details the process science skills he intends to develop and the ways in which he will do it. Students swap plans and discuss them. Questions to Case Study Why do you think future teachers need to know the process science skills theory? Do you remember what process science skills were developed in you when you were students? How did your physics 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.

Chapter 2 : READ Learning and Assessing Science Process Skills PDF ONLINE - Video Dailymotion

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Scientific experimentation and observation have come to be defined by the exercise of a process called the scientific method. The underlying skills and premises which govern the scientific method are referred to as science process skills. Science process skills refer to the following six actions, in no particular order: These basic skills are used in the experiments of scientists and students, as well as into the everyday life of average person, to a degree. They allow everyone to conduct objective investigation and to reach conclusions based on the results. The first of the science process skills, observation, involves noting the attributes of objects and situations through the use of the senses. Classification goes one step further by grouping together objects or situations based on shared attributes. Measurement involves expressing physical characteristics in quantitative ways. Communication brings the first three skills together to report to others what has been found by experimentation. Ad Inference and prediction are the more sophisticated of these skills. Beyond simply seeing and reporting results, scientists must extract meaning from them. These skills can involve finding patterns in the results of a series of experiments, and using experience to form new hypotheses. It is also essential for a scientist to be able to distinguish his objective observations from his inferences and predictions. This is because scientific inquiry and study depend on objectivity and an avoidance of hasty assumptions in experimentation. All of the science process skills contribute to a larger purpose, namely problem solving. Problem solving is the reason for scientific inquiry, and forms the essence of it. A typical experiment wherein a scientist uses process skills and the scientific method will start with certain questions being asked. Based on prior knowledge and experience, the scientist will make an educated guess as to the answer or outcome. This hypothesis will guide the design and execution of an experiment. Once the experimental variables have been determined, they can be isolated and controlled. Conclusions drawn based on accurate data collection during the procedure can lead to the hypothesis being verified or proven incorrect. Experience will show a scientist that different conclusions can be drawn from the same set of observations, and still be correct.

Chapter 3 : IQST | E-learning | Development Procedural Skills in Science Education (BG)

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Research Matters - to the Science Teacher No. All school subjects should share in accomplishing this overall goal. Science contributes its unique skills, with its emphasis on hypothesizing, manipulating the physical world and reasoning from data. The scientific method, scientific thinking and critical thinking have been terms used at various times to describe these science skills. Today the term "science process skills" is commonly used. Popularized by the curriculum project, Science - A Process Approach SAPA , these skills are defined as a set of broadly transferable abilities, appropriate to many science disciplines and reflective of the behavior of scientists. SAPA grouped process skills into two types-basic and integrated. The basic simpler process skills provide a foundation for learning the integrated more complex skills. These skills are listed and described below. Basic Science Process Skills Observing - using the senses to gather information about an object or event. Describing a pencil as yellow. Inferring - making an "educated guess" about an object or event based on previously gathered data or information. Saying that the person who used a pencil made a lot of mistakes because the eraser was well worn. Measuring - using both standard and nonstandard measures or estimates to describe the dimensions of an object or event. Using a meter stick to measure the length of a table in centimeters. Communicating - using words or graphic symbols to describe an action, object or event. Describing the change in height of a plant over time in writing or through a graph. Classifying - grouping or ordering objects or events into categories based on properties or criteria. Placing all rocks having certain grain size or hardness into one group. Predicting - stating the outcome of a future event based on a pattern of evidence. Predicting the height of a plant in two weeks time based on a graph of its growth during the previous four weeks. Integrated Science Process Skills Controlling variables - being able to identify variables that can affect an experimental outcome, keeping most constant while manipulating only the independent variable. Realizing through past experiences that amount of light and water need to be controlled when testing to see how the addition of organic matter affects the growth of beans. Defining operationally - stating how to measure a variable in an experiment. Stating that bean growth will be measured in centimeters per week. Formulating hypotheses - stating the expected outcome of an experiment. The greater the amount of organic matter added to the soil, the greater the bean growth. Interpreting data - organizing data and drawing conclusions from it. Recording data from the experiment on bean growth in a data table and forming a conclusion which relates trends in the data to variables. Experimenting - being able to conduct an experiment, including asking an appropriate question, stating a hypothesis, identifying and controlling variables, operationally defining those variables, designing a "fair" experiment, conducting the experiment, and interpreting the results of the experiment. The entire process of conducting the experiment on the affect of organic matter on the growth of bean plants. Formulating models - creating a mental or physical model of a process or event. The model of how the processes of evaporation and condensation interrelate in the water cycle. Learning basic process skills Numerous research projects have focused on the teaching and acquisition of basic process skills. For example, Padilla, Cronin, and Twiest surveyed the basic process skills of middle school students with no special process skill training. Several researchers have found that teaching increases levels of skill performance. Thiel and George investigated predicting among third and fifth graders, and Tomera observing among seventh graders. From these studies it can be concluded that basic skills can be taught and that when learned, readily transferred to new situations Tomera, Teaching strategies which proved effective were: In other words-just what research and theory has always defined as good teaching. Other studies evaluated the effect of NSF-funded science curricula on how well they taught basic process skills. Studies focusing on the Science Curriculum Improvement Study SCIS and SAPA indicate that elementary school students, if taught process skills abilities, not only learn to use those processes, but also retain them for future use. Researchers, after comparing SAPA students to those experiencing a more traditional science program, concluded that the success of SAPA lies in the area of improving process oriented skills Wideen, ;

McGlathery, Thus it seems reasonable to conclude that students learn the basic skills better if they are considered an important object of instruction and if proven teaching methods are used. Learning integrated process skills Several studies have investigated the learning of integrated science process skills. Allen found that third graders can identify variables if the context is simple enough. Both Quinn and George and Wright found that students can be taught to formulate hypotheses and that this ability is retained over time. Others have tried to teach all of the skills involved in conducting an experiment. Padilla, Okey and Garrard systematically integrated experimenting lessons into a middle school science curriculum. One group of students was taught a two week introductory unit on experimenting which focused on manipulative activities. A second group was taught the experimenting unit, but also experienced one additional process skill activity per week for a period of fourteen weeks. Those having the extended treatment outscored those experiencing the two week unit. These results indicate that the more complex process skills cannot be learned via a two week unit in which science content is typically taught. Rather, experimenting abilities need to be practiced over a period of time. Further study of experimenting abilities shows that they are closely related to the formal thinking abilities described by Piaget. In fact, one of the ways that Piaget decided whether someone was formal or concrete was to ask that person to design an experiment to solve a problem. We also know that most early adolescents and many young adults have not yet reached their full formal reasoning capacity Chiapetta, What have we learned about teaching integrated science processes? We cannot expect students to excel at skills they have not experienced or been allowed to practice. Teachers cannot expect mastery of experimenting skills after only a few practice sessions. Instead students need multiple opportunities to work with these skills in different content areas and contexts. Teachers need to be patient with those having difficulties, since there is a need to have developed formal thinking patterns to successfully "experiment. In general, the research literature indicates that when science process skills are a specific planned outcome of a science program, those skills can be learned by students. Teachers need to select curricula which emphasize science process skills. In addition they need to capitalize on opportunities in the activities normally done in the classroom. While not an easy solution to implement, it remains the best available at this time because of the lack of emphasis of process skills in most commercial materials. An examination of the ability of third grade children from the Science Curriculum Improvement Study to identify experimental variables and to recognize change. Science Education, 57, A review of Piagetian studies relevant to science instruction at the secondary and college level. Science Education, 60, An assessment of science achievement of five and six-year-old students of contrasting socio-economic background. Research and Curriculum Development in Science Education, , Effect of laboratory activities and written simulations on the acquisition of graphing skills by eighth grade students. The relationship between science process skills and formal thinking abilities. Journal of Research in Science Teaching, The development and validation of the test of basic process skills. Science Education, 59, Science Education, 62, Some factors affecting the use of the science process skill of prediction by elementary school children. Journal of Research in Science Teaching, 13, Transfer and retention of transfer of the science processes of observation and comparison in junior high school students. Science Education, 58, Comparison of student outcomes for Science - A Process Approach and traditional science teaching for third, fourth, fifth, and sixth grade classes: Journal of Research in Science Teaching, 12, The long-term effects of intensive instruction on the open exploration behavior of ninth grade students.

Chapter 4 : Learning and Assessing Science Process Skills by Richard J. Rezba

The book includes an appendix with materials and equipment that can be used for learning and assessing science process skills. This book is designed to help teachers know how to develop necessary science knowledge and skills in their students.

Many thanks to the author for submitting this manuscript in HTML format. Karen Ostlund The University of Texas at Austin Scientists engage in procedures of investigation to gain knowledge of natural phenomena. These tactics and strategies, the skills scientists use in their pursuit of understanding, are summarized below: Science begins with observations of objects and events; these observations lead to the asking of questions. Crucial to the method of science is the ability to ask the right question and to make selected observations relevant to that question. Observations are influenced by past experience, often involve instruments microscopes, telescopes, oscilloscopes, etc. Surprising or unexpected observations occasionally contribute new an d important knowledge. Measurement involves assigning numbers to objects or events that may be arranged in a continuum according to a set of values. Expression of observations in quantitative terms adds precision and permits more accurate descripti ons. An experiment is a series of observations carried out under special conditions. The distinction between observation and experimentation is slight. An experiment always consists of observations, but it is more than that be cause the observers usually interfere to some extent with nature. Experimentation is the hallmark of good science whether it comes at the beginning - as a gathering of facts - or at the end in the final test of a hypothesis. A scientist is obligated to make the information from observation and experimentation available to the scientific community for independent confirmation and testing. Discussion and critical analysis of findings are the key means by which science advances. Scientists disseminate their results in journals, at professional meetings, seminars, and through informal networks. This dissemination contributes to the common core of knowledge of the past and provides the vehicle for c ontinuous review of this body of knowledge. Communication is the means by which purpose and usefulness are given to scientific investigation. Although the boundaries are hazy, it appears that certain thought processes are part of the common pattern of scientific investigation. These include inductive reasoning, formulation of hypotheses, deductive reas oning, and a variety of mental skills such as analogy, extrapolation, synthesis, and evaluation. In addition to these traditional processes, scientific inquiry abounds with approaches described variously as speculation, guess, intuition, hunches, or insig ht. The exact mechanisms by which these processes function are unknown but they are commonly cited in the autobiographies of the great scientists. Reading and activity-oriented science emphasize the same intellectual skills and are both concerned with thinking processes. When a teacher helps students develop scientific processes, reading processes are simultaneously being developed. The research on strategies and methodologies for teaching science in elementary schools has produced clear evidence that students in process-approach programs learn more than do students in traditional textbook-based programs Bredderman, Data from meta-analyses by Shymansky et al. The gains in attitude and process skills make sense, considering the emphasis placed on making science fun through hands-on activity. However, the programs were generally seen as lacking rigor-a point which ultimately contributed to their demise. The data indicate that, in fact, these elementary science programs were more effective in enhancing student achievement and problem-solving s kills than were traditional programs. The data that profile the combined effect of ESS, SCIS, and SAPA on student subgroups show that students in both rural and urban classrooms with equal distributions of boys and girls from medium and high socio-economi c backgrounds performed significantly better than did their counterparts in traditional science programs. On standardized tests, students involved in at least one of the three programs performed significantly better on the composite measure and on three o f the five performance areas. Osborne and Freyberg outline five techniques that teachers in activity-based programs have used successfully to get students to focus on strategies for learning how to learn through activities. For example, instruction or a particular task can b e written on cards and handed to small groups of students for unscrambling. Five to ten minutes spent on this kind of activity ensures that students will think about what to do rather than merely go

through mechanical motions. Effects of activity-based elementary science on student outcomes: Review of Educational Research, 53 4 , Journal of Research in Science Teaching, 20, Science Process Skills How can teaching science process skills improve student performance in reading, language arts, and mathematics? The science process skills are part of and central to other disciplines. Research indicates that the integration of science with reading and mathematics has produced positive effects on student learning: Of the three areas within the skill-complex, two can be directly enhanced by science process skills: These skills then contribute to the development of the concepts, vocabulary, and oral language skills listening and speaking necessary for learning to read Wellman, The attainment of process skills developed by such science experiences are positively correlated with the development of re ading readiness Nicodemus, ; Ritz, ; Rowe, ; and Stafford, Children who were exposed to Science- A Process Approach out-performed students who were not in tests of language output, vocabulary, sentence structure, and classifying, transmitting, and receiving oral communication skills. Mathematics, to a great extent, is the language of science. In addition, science experiences contribute to the development of other operations basic to t he study of mathematics. Some of these operations are: Students who had mathematics-science programs performed better on conservation and transitivity tasks than did those who received only mathematics instruction Almy, Replacing contrived problems with real-world science problems has the potential to enhance the problem-solving abilities of st udents, while promoting a greater appreciation of the usefulness of problem solving in a multitude of circumstances Coffia, and Shann, Summary The concepts, processes, and methods found in science are used in other disciplines. Students read textbooks, read directions for conducting experiments, and writ e their own reports of observation. School Science and Mathematics The Reading Teacher Children learning to read should experience science. Science inquiry and the development of classification and oral communication skills in inner-city children. Doctoral Dissertation, University of Pennsylvania. A study of the relationship of reading ability of students in grades 4, 5, and 6, and comprehension of social studies and science textbook selections. Doctoral Dissertation, Florida State University. Doctoral Dissertation, University of Oklahoma. Curriculum experiences and movement from concrete to operational thought. In Research, teaching, and learning with the Piaget model. University of Oklahoma Press. The effects of the use of activities of SAPA on the oral communication skills of disadvantaged kindergarten children. Journal of Research in Science Teaching A study of information and vocabulary achievement from the teaching of natural science by television in the fifth grade. Dissertation Abstracts International Effects of a supplemental science program on achievement of students with different socioeconomic and ethnic background. Doctoral Dissertation, Oklahoma State University. The new science methods and reading. Science teaches basic skills. National Science Teachers Association. The acquisition of reading, cognitive, linguistic, and perceptual prerequisites. National Council of Teachers of Mathematics. An agenda for action: Recommendations for school mathematics of the s. Theory into action in science curriculum development. Position statement on science-technology-society: Science education for the s. A profession speaks, ed. An evaluation of elementary science study as Science-A Process Approach. Washington Academy of Science ED The effect of kindergarten science experiences on reading readiness, final report. The relationship between science education and language development. The effect of two instructional programs Science-A Process Approach and the Frostig Program for the Development of Visual Perception on the attainment of reading readiness, visual perception, and science process skills in kindergarte n children. An inquiry approach to science and language teaching. SCIS in the inner-city school. Evaluation of an interdisciplinary problem-solving curriculum in elementary science and mathematics. Science and Children 18 No. The influence of the first grade program of the Science Curriculum Improvement Study on the rate of attainment of conservation. Improving reading in science. Formal operational thinking of gifted students in grades 5, 6, 7, and 8. A basic for language and reading development. In What research says to the science teacher, vol. To get to the top of this page, click here. To get back to the current issue of the EJSE, click here.

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