MANHATTAN PUBLIC SCHOOLS SCIENCE CURRICULUM

Overview

The Manhattan Public Schools Science Curriculum is centered on the Next Generation Science Standards (NGSS) that was finalized in March of 2013. All Manhattan K-12 teachers of science provided input in terms of instructional content in their classroom regarding coverage of NGSS. The document that follows this represents teachers input and alignment with NGSS.

Three important areas for Manhattan teachers of science include providing opportunities for students to engage in high level scientific and engineering practices, utilize cross cutting concepts and provide opportunities for all students in disciplinary core ideas of Physical, Life, Earth and Space science in addition to Engineering Technology and Applications of Science (Pratt, 2013).

Having students engage in scientific and engineering practices means that teachers of science should be defining and utilizing practical-based problems and applications throughout the science curriculum (engineering). This would mean that teachers and students would be developing appropriate models, planning and carrying out "hands-on, minds-on" investigations that are inquiry-based in nature. Students should be practicing "good" science methodology within the framework of the NGSS. A focus in this process is having students use mathematics, technology and computational thinking in analyzing and interpreting data. From this data, students should construct explanations and design solutions, and also engage in arguments from the evidence. An important component will be obtaining, evaluating and communicating the information.

Cross cutting concepts involves identifying patterns and "cause and effect" relationships that might exist within one discipline, and might be applied to another discipline. The physical and chemical nature of the atmosphere when teaching an earth science topic like weather might serve as a good example. It will be important in this process to teach, model, and assess student understanding of scale, proportion, quantity, and to help build these into a systems model. Energy and matter are present throughout all science disciplines and student understanding of the flows, cycles, and conservation will be important in all science units. A focus in the K-5 grades is finding ways of teaching science through other disciplines like reading, mathematics, social studies, writing, art and music.

The disciplinary core ideas presented in this document are coded:

Physical Science

PS1: Matter and it's interactions

PS2: Motion stability: Forces and interactions.

PS3: Energy

PS4: Waves and their applications in technologies for information transfer.

<u>Life Sciences</u>

LS1: From molecules to organisms: Structures and processes.

LS2: Ecosystems: Interactions, energy, and dynamics.

LS3: Heredity: Inheritance and variations of traits.

LS4: Biological evolution: Unity and diversity.

<u>Earth and Space Sciences.</u>

ESS1: Earth's place in the universe.

ESS2: Earth systems.

ESS3: Earth and human activity.

<u>Engineering, Technology, and the Applications of Science.</u>

ETS1: Engineering design.

ETS2: Links among engineering, technology, science, and society

(Source: NRC 2012, p. 3).

<u>Best Practices in Science Education</u>

Some ideas for integrating best practices into the Manhattan curriculum might serve as a guidepost to increase further thinking. Some ideas include:

<u>Realize that the family becomes the most important factor in a students' success.</u>

Parents raise their children and spend much more time with them than teachers of science. It is therefore important that teachers realize this and support the parents as much as possible. This support might take the form of helping parents understand some goals of high quality science instruction, keeping them informed and involved in their child's education in the classroom, and keep them informed of informal science opportunities such as family science nights and museum visits. Whenever possible, a goal of "taking science home" in terms of demonstrations, experiments, "a flipped classroom," etc. are worthwhile outcomes. Engaged families help to develop an engaged student, and one interested in a Science-Technology-Engineering-Mathematics future (STEM).

<u>Distinguish between learner outcomes and instructional strategies.</u>

High quality instruction can better happen if the teacher identifies which part of the lesson are learner outcomes and which part become instructional strategies to help the learner succeed in these learning targets. A teacher will need to identify ways to integrate the above learning outcomes of practices, crosscutting concepts, and core ideas into their unit and lesson plans (Bybee, 2013).

<u>Use an integrated instructional sequence such as Biological Sciences Curriculum Study (BSCS).</u>

The BSCS Instructional Model (Bybee 2013, p. 58)

Engage
The engage lessons initiate the instructional sequence. An engaging activity should (1) activate prior knowledge and make connections between the students' past and present learning experiences, and (2) anticipate activities and focus students' thinking on the topics and learning outcomes in the forthcoming lessons. The learner should become mentally engaged with the science ideas, concepts, and practices of the instructional unit.
Exploration
The exploration should provide students with a common base of experiences within which they identify and begin developing science ideas, concepts, and practices. Students actively explore the contextual situations through investigations, reading, web searches, and discourse with peers.
Explanation
These lessons develop an explanation for the concepts and practices students have been exploring. The students verbalize their conceptual understanding and demonstrate their scientific and engineering practices. Teachers introduce formal labels, definitions, and explanations for concepts, practices, skills or abilities.
Elaboration
The elaboration lessons extend students' conceptual understanding through opportunities to apply knowledge, skills and abilities. Through new experiences, the learners transfer what they have learned and develop broader and deeper understanding of concepts about the contextual situation and refine their skills and abilities.
Evaluation
This segment of the instructional sequence is based on the performance expectations and emphasizes students assessing their ideas, concepts, and practices. The evaluation also includes embedded assessments that provide feedback about the degree to which students have attained the competencies described in the performance expectations.

The above instructional model represents one technique. Teachers of science in Manhattan are encouraged to develop a teaching "toolkit" that contains many such instructional models that can be used in a variety of situations, with a variety of different lessons and with a group of diverse learners. Such a "toolkit" is needed for differentiation in our science classrooms.

Use a "Backward Design"

Begin by identifying performance expectations and learning outcomes. Consider what the NGSS states about the particular topic, then work backward to plan assessment, adequate unit, and lesson plans. This process should be used through all stages of instruction and particular emphasis should be placed on addressing a variety of learning styles with students who are developmentally in different stages (Wiggins & McTighe 2005).

Emphasize student motivation throughout the learning process

Teachers who engage students to want to learn more about the subject matter will help foster a more productive learning atmosphere. Science, with it's engaging demonstrations and activities, becomes a natural medium to foster high motivation. The goal of teachers of science is to encourage and create this motivation and cause students to want to learn more science once they leave our classrooms.

Integrated within science lessons should be a focus on science literacy and career awareness.

In our fast developing technological world, STEM lessons become more important than ever. It is important that teachers of science integrate information that will help make the next generation of voting citizens informed as to the science impact of various policy decisions. Emphasizing the argumentative nature of science inquiry is an excellent way to do this, and also frequent inclusion of the Nature of Science (NOS) is very effective. Also, within this goal is to design into lessons information about STEM careers connected to various science units. Once a student makes some decisions as to a future career, their engagement level and future course of action is partially planned. As teachers are covering their lessons, information should be provided as to types of careers, educational preparation for the career in addition to support for students who wish to pursue individual pathways to a career (Sally Ride Science, 2010).

ASSESSMENT

A very important component to a high quality curriculum and exemplary science teaching is assessment. Teachers need to measure the knowledge of their students. The six domains of science are important to consider as teachers plans their assessment procedures (Enger & Yager, 2001). The domains are (pp. 2-13):

Concepts- The facts, laws, theories and student knowledge would fall under this domain. Teachers who use various assessments like multiple-choice items, short answer, essay type questions would be assessing the conceptual areas of science.

Process – Inquiry skills, exploring and investigating all fall under this domain. Teachers who utilize performance assessments, lab investigations, observations rubrics, etc fall could be in this domain.

Application – To what degree can students transfer what they have learned to their everyday lives? When we ask students to use critical thinking skills, use of scientific processes in solving problems and applications of technological problems are good ways teachers can address these issues.

Attitude – Experiences that explore human emotions, decisions about personal values and environmental issues and just helping to create a positive attitude towards STEM careers is a goal of this domain. Class evaluations and Likert surveys are good ways to evaluate this.

Creativity – When we encourage students to experience visualization, divergent thinking, alternate viewpoints and some of the many design challenges in engineering are wonderful ways to assess this domain.

Nature of Science – This domain could support the entire approach to a science curriculum. If teachers approach science learning as the discovery process that it is, then they are addressing the Nature of Science. It is also important to provide learners with the historical context in which concepts were discovered. Teachers who have students competing in science fairs, independent research projects, etc are helping to create awareness in this domain.

The above domains tie nicely into to main categories of assessment, formative and summative.

Formative

Formative assessment becomes the assessment that teachers use to check student understanding. Teachers in class discussion questions become a source of formative assessment. In addition there are hundreds of quick easy formative assessments that should be added to all teachers of science "toolkits" (Angelo & Cross, 1993; Keeley, 2006). Some of the common techniques used Manhattan teachers include: *Thumbs up; Thumbs down* – just as the name implies, if students understand a concept they put their thumbs up or down. *Muddiest Point* – Students are asked what information is not clear. This can be used with a lesson, a test, lab, most anytime a teacher wishes some feedback. *One Sentence Summary* – students are asked to write in one sentence what they thought the meaning of a particular concept or lesson was. The teacher by reading these can tell the degree of student understanding. *Minute Paper* – Students are given one minute to respond to the questions, "What was the most important thing you learned during this class?" and often a second question, "What important question remains unanswered?" *White boards* – These are used to solicit information and are especially useful as students can be asked to draw concepts which can lead into higher level thinking skills. *Back ground Knowledge Probe* – These are useful when starting a new unit as they help to show what students already know. *Concept Maps*- These can be useful to show learners how well they understand how various science concepts, vocabulary and terms fit together. *Exit Tickets* – Students must complete an activity (like one of these formative assessments) prior to leaving the room or starting work on a lab. *Misconception/Preconception Check* – Misconceptions are very common in science and these are helpful to uncover such ideas. Closely related to this are the *Probes* devised by Page Keeley (2001-2005). For ideas on all these and many more (over 400) check the Angelo & Cross book and the Keeley books.

<u>Summative</u>

The major point-based assessments that teachers use become the summative part of assessment. Teachers are encouraged to use a variety of summative assessments including, but not limited to: multiple-choice items, norm and Criterion-Referenced Evaluations, essay and short answer assessments, lab performance-based assessment, and alternative assessments. Alternative assessments might take the form of graphic organizers like Venn or Vee diagrams, portfolios, group projects, research-based projects. In all assessments teachers are encouraged to progress students towards higher level thinking orders like synthesis, analysis and evaluation.

Students also take a science state test in the spring of each year. The test is administered by Montana Office of Public Instruction, and this department also track state scores.

The overall goal of a strong science curriculum is to provide teachers of science with some guideposts in terms of what instructional items they should be focused on. It is important in this process that the curriculum should be flexible enough that teachers have the ability to include their own creativity, teaching style and expertise in. Hopefully that is the goal of the Manhattan School Science Curriculum.

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Course Descriptions

7th Grade Science – A year-long course which focuses on Earth Science and Life Science topics. The emphasis is on how changes in landforms impact changes in life forms. A focus is placed on inquiry-based hands on experiences as students explore various concepts in Earth Systems science, plus major classifications and concepts in life science. Several months are also spent on topics like forces, velocity, acceleration, pendulums and simple machines.

7th Grade Applied Science – This semester long course is divided into several modules. A major portion is dedicated to lessons in Meteorology, students are taught an infant, child and adult community CPR course, and the reminder of the semesters is dedicated to a wave and sound unit. This class also has an outcome of an independent science research project, and numerous design challenges.

8th Grade Science - This year-long class is broken in several units. Chemistry, heat and light, electricity, astronomy and human biology are all taught with an emphasis on inquiry-based hands on experiences. Learners are challenged to develop critical thinking skills and also taught science process skills.

8th Grade Applied Science - This semester long course is divided into several modules. Ecological principles and concepts are taught with an emphasis on outdoor experiences and exploration. A First Aid class which includes adult CRP/AED is also taught, and all students complete an independent science research project which is presented in a science symposium. This class also investigates numerous design challenges.

Biology – A year-long course studying living things and its biological components. The content will emphasize Cell and Cell Theory, Cell Function, Reproduction, Adaptation and Natural Selection, Genetics, Classification and Taxonomy of Organims, Hierarchy of Order, and Ecology.

Chemistry – A year-long course studying the chemical nature of matter. The content of the course will explore: Atomic Structure, Periodicity, Chemical Properties of Matter, Mole Concept and Stoichiometry, Bonding and Energy, Solutions and Gas Laws.

Physics – A year- long course emphasizing study of energy and its relationship with the universe. The content will emphasize: forces, mechanics, relativity, waves, electricity, optics, nuclear physics, and thermodynamics.

Advanced Biology – a year-long course with an emphasis in levels of structural organization, homeostasis, and genetics. It also includes emphasis with the integumentary, skeletal, musculatory, nervous, endocrine, cardiovascular, respiratory, excretory, digestive, and reproductive systems.

Earth Science – A year-long course designed to study the Earth and its part of the Universe. The content of this course will include: Astronomy, Geology, Oceanography, Meteorology and Climatology, and Historical Geology.

Environmental Science – A semester course designed to explore the scientific approach to environmental issues that affect the Earth. The study will include: Ecology, Resource Use and Management, Pollution, and the Economic effects on the economies of the United States and the State of Montana.

Physical Science – A semester course designed to give students an opportunity to explore and review the basic concepts of Chemistry and Physics. The content will include the chemical and physical properties of matter, and the study of energy and its relationship with the earth and universe.