Lesson plans: Learning and the Sciences

I. The medieval curriculum

a. During the Middle Ages, the curriculum of study was divided into two parts: the *trivium* (grammar, logic, and rhetoric), and the *quadrivium* (arithmetic, geometry, music, and astronomy). These were the seven “liberal arts,” and were based on a classical Greek model of learning.

i. Here is a personification of the trivium. Grammar is lecturing a small student and holding a kind of bat (she is often shown with a whip to encourage her students!); Logic holds a snake to symbolize crafty argument; Rhetoric has armor and spears to demonstrate the power of well-deployed words. In personifications of the quadrivium, Arithmetic often has a ruler; Geometry is frequently shown with compasses, a globe, or other measuring tools; Music generally has a musical instrument of some kind; and Astronomy has wings and a crown of stars.

b. Thinkers from the Islamic world, also working from Greek origins, influenced the Western medieval view of how knowledge was structured. Al-Ghazali (a Persian philosopher of the eleventh century, known to the West as Algazel) proposed a division of knowledge into divine and natural science, and in this passage he further divides up the natural sciences:

“...Natural science has several branches, such as medicine, images, incantations, charms, etc. On the other hand, the subject of mathematics is universally quantity, but variously magnitude and multitude, so mathematics also has several roots and branches, but the roots are the science of geometry, the science of number, and the science concerning the form of the world, namely astrology and music, and its branches are the science of vision, the science of craftsmanship, and the science that concerns engineering, etc.

Mathematics is further removed from doubt and error; for natural [science] is more impeded, because natural things are always in change because they are separated from certitude, which does not occur in mathematics.”

c. Medieval thinking on the organization of the sciences often covered not only how the various sciences were related to one another, but also their relative rankings of importance. The twelfth-century Arab philosopher and scientist Ibn Rushd (known as Averroes in the West) proposed hierarchies based on how exact sciences were, and how noble their subject matter was: “For sciences do not differ from one another except in one of these two ways: namely either in corroboration of their demonstrations or in the nobility of their subject, or in both. For example, geometry exceeds astrology through the corroboration of its demonstration, but astrology surpasses the other in the nobility of its subject.”

d. Discussion: How would you organize a modern-day trivium and quadrivium? What are some subjects we study in school today that the medieval curriculum did not include? Are there subjects they studied that we no longer learn in school?
II. Music

a. Medieval Europe had an active and varied musical culture, both sacred and secular. (For more information on medieval sacred music, see lessons on the medieval church.) Medieval musicians had a wide variety of instruments available to them, some of which had been around since antiquity and some of which were newer, many inspired by instruments from Asia and the middle East: stringed instruments (harps, dulcimers, viols), wind instruments (shawms, flutes, bagpipes), and percussion instruments (drums, tambourines). Maybe you are already familiar with those instruments, but what do you think the lizard, zink, sacbut, and crumhorn sounded like? Check out this page for pictures and sound clips of modern-day reconstructions of many medieval instruments.

i. A medieval musical text showing notes from the opposite page, and a figure of a hand showing the different notes. This hand was the “Guidonian hand,” devised by an Italian monk in the eleventh century to help students learn the notes by counting them off on the joints of the hand.

ii. Man playing viol:

iii. David with musical bells, harp, and psaltery:

iv. Girls playing the tambourine:

v. Many medieval texts contained fanciful illustrations of animals such as monkeys and dogs playing instruments; here a donkey playing the harp, an illumination from a 13th century Bible, is shown.

b. Music was a particularly important part of the medieval curriculum because the study of musical harmony was akin to the study of mathematics, and so was related to the study of the celestial harmony of the universe, the “music of the spheres”. Medieval thinking about this subject developed from the philosophical work of Plato and Aristotle, as can be seen in this excerpt from "On the Music of the Spheres" by William of Auvergne:

“Plato applied and adapted numbers to the form of that soul, and he stated that they enter, as it were, into its composition from the very fabric of the world, for which he held such a soul, as he is seen to have admitted. For he held ... that the whole world and its parts are musical, according to what I could understand about him, naturally suited and connected to one another in harmonious proportions. ... He was guided by the force and power of harmonious proportions, which are, as he said, so powerful in our souls that our whole souls seemed to be placed in their power. They do, of course, change them with a marvelous ease in terms of the dispositions that are in the concupiscible [desiring] and irascible [getting angry] power, and they do this at the desire or pleasure of the musician, if he is trained and clearly expert in the musical art. For they change them with an incredible speed from sorrow to joy, and the converse, from turbulence to tranquility and serenity, from fear to hope or confidence, from pusillanimity to magnificence, and the converse.”

i. Heavenly spheres in an astronomy text

c. Discussion: The idea that music has a special power over our minds is still with us today, though most of us probably don’t think it has much to do with the harmonies of the
universe. Can you think of a song or piece of music that makes you feel happy? Sad? Angry? Do you play a musical instrument, or know someone who does? (Playing “Rock Band” or “Guitar Hero” may or may not count – do you think these games evoke the same emotional engagement as playing an instrument? What factors do the two types of activities have in common, and what are the differences between them?)

III. Mathematics
   a. Both arithmetic and geometry were part of the quadrivium; just as they do today, arithmetic taught about manipulating numbers through techniques like multiplication, while geometry taught about measuring areas and volumes. As you have already seen for other subjects of study, much of the mathematics done in medieval Europe came from the Islamic world, where translations of the Greek mathematical authors were studied and expanded. One name you may recognize from this era is Fibonacci, whose real name was Leonardo of Pisa. This thirteenth-century Italian mathematician spent time as a young man with his father in north Africa, where he became acquainted with the Hindu-Arabic numerical system. This system, quite close to the one we use today, was much easier to use than Roman numerals; among other things, it had a zero (imagine trying to do mathematics with no zero!). Leonardo’s famous book was the Liber abaci, or “book of the abacus.” In this book, he introduced the Hindu-Arabic numerical system to the West, including as an example of a calculation the traditional numerical sequence that now bears the name of Fibonacci. This sequence is developed by starting with [0,1] and adding each number to the last to produce the next: [0,1,1,2,3,5,8,...]. If you are interested in learning more about the Fibonacci sequence, and its amazing appearance in nature, Ron Knott’s page is a great place to start.
      i. **God creating stars using compass**
      ii. **T-square** for use in geometrical constructions
      iii. **Application of geometry**: building castle towers
   b. Spend some time exploring this history of mathematics site. While you’re doing this, discuss some aspects of mathematics that are the same throughout history, and aspects that are different. Think back to Al-Ghazali’s claim that mathematics is without error, and to claims that mathematics is “the universal language.” Think of a few arguments in favor of this claim, and a few arguments against it.

IV. Astronomy
   a. Astronomy was an important science in medieval times; not only did studying the stars and planets help with practical tasks like navigation and marking the seasons, but medieval astronomers used their observations, and those of the ancient Greeks who came before them, to try to understand the structure of the universe. Medieval astronomical plans look very different from modern maps of the solar system. Among other factors such as the lack of modern observational technology, medieval astronomers were mostly committed to the Church-approved view that the earth was at the center of the universe, while the sun and other planets revolved around it (but for an interesting exception, see what Hildegard of Bingen had to say about it below).
i. Here a student learns astronomy by observing the stars while his teacher lectures using a model of the heavens.

ii. Sundial

iii. Diagram of the planets

iv. Comets

b. Hildegard of Bingen writes about the arrangement of the planets in the heavens in a way that suggests a modern heliocentric solar system: “There are also five other planets, and they have light from the fire and from the ether and they are sturdy and the support of the firmament. And they have they have orbits of as much height as depth in the firmament, that they shine there, where the sun does not shine and its luster hardly reaches where they are. They rush and are slaves to the orbit of the sun and they maintain the speed of the sun and they make its fire dwindle away, so thus because of them it does not emit so much heat from its fire, as it would do, if they did not restrain it. And like the five senses of the human body surround the body and are ornaments of it, so too those five planets surround the sun and are its ornament. But the firmament is also revolving quickly, and the sun, with the other planets, rushes little by little against it and opposite to it and restrains its speed; because if the sun did not restrain it by slowing it or if, along with the other planets, it rushed with such speed against the firmament, that it turned around, everything would be mixed together, and the firmament would be completely shattered.”

c. During medieval times as in classical times, the disciplines of astronomy and astrology were not separated as they are today. However, Christianity frowned upon fortune-telling as a kind of sorcery, so this aspect of astrology was diminished in medieval works on astrology. The text by Hildegard of Bingen that you have just read on astronomy goes on to talk about what we would now call astrology, and you can see how she draws the line between astronomy and astrology:

“In fact, the stars now and then reveal many signs on themselves of how men, in their works, are conducting themselves at the time. But they neither reveal the future nor the thoughts of men, but these things only: that which a man does either with by his clear free will, or in his voice or his deeds, because the air snatches up these things. And the air brings them to the stars, with the result that in this way they immediately display the works of a man. God, however, made the stars for the servitude of man, so that they may shine and attend to him. And therefore they also display his deeds, just as a servant makes visible the will and work of his master. For just as the spirit first shines in the body of a man and then proceeds to a deed, so also do the stars shine in the firmament and reveal the works of a man, when a man is working.”

d. Discuss these two texts of Hildegard. What does she say that would be regarded by a modern audience as “scientific,” and what would we call “unscientific”? What do you think was the worldview behind Hildegard’s ideas about astronomy? The Church was certainly a more visible force in medieval science than modern science, but even today science and religion are not always viewed as irreconcilable. Some of these sites may be
useful as you explore these issues: Einstein and Religion, Freeman Dyson’s “Progress in Religion”, and of course the intelligent design controversy.