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AUTHOR Struthers, Sally A.
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ABSTRACT

While interdisciplinary courses can help demonstrate the relevance of learning to students and reinforce education from different fields, they can be difficult to implement and are often not cost effective. An interdisciplinary art history course at Ohio's Sinclair Community College incorporates science into the art history curriculum, making use of computer and multimedia presentation techniques. The course presents slides depicting Leonardo da Vinci's scientific interests through sketches and notes about military engineering, botany, the flight of birds, horses, animal and human dissections, optics, geology, geography, proportions, hydraulics, and flight. Six paintings are utilized in the course to represent the artist's general and specific interests throughout the span of his career. These paintings provide evidence of the artist's knowledge of anatomy and ability to capture scientific images in detail. Some of the images presented are facial bone structure, effects of light and shade relating to structure, color, and value contrasts, landscape, bone structure of hands and feet, geology, plants and flowers, animals, and the human eye. In addition to the traditional slide and lecture format, computers are also used to demonstrate the integration of art and science. Since the team approach in teaching interdisciplinary studies may be difficult to implement, instructors may explore and share different interdisciplinary models available through computer technology. In addition, multimedia computer programs are preferred over traditional textbooks by art history students. (TGI)

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Scientific Aspects of Leonardo da Vinci's Drawings: An Interdisciplinary Model

Sally A. Struthers, Ph.D.
Sinclair Community College

Much has been said of the advantages of interdisciplinary studies: that they demonstrate the relevance of learning to the student; they show how different fields impact one another, and to reinforce that education; and that the world is not the sum of individual cells of information functioning autonomously, but a mesh of integrated components.

True interdisciplinary courses are, in my opinion, the most beneficial, but also the most difficult to plan and implement. One reason is that usually at least two professors are necessary for true interdisciplinary studies since we usually only have one special area of expertise. Team-taught courses are difficult to plan, and, from my experience, those course plans evolve due to the dynamics of the interaction between the professors and students.

A course that was very successful (from the students' view) at my institution, Sinclair Community College, was an honors seminar on "Freud, Einstein, and Darwin: Influential Thinkers", taught by three professors from psychology, physics, and biology. Another interesting honors course was the "Psycho-Chemical Connection", taught by professors from psychology, chemistry, and biology. One problem with both courses was that they were not cost effective. Many of our students do not stray from the basic courses necessary in their path toward graduation, so enrollment was not peak. We usually need an

average class size of 18, and that is what we had for these classes, but 3 instructors to pay. The course is usually 3 payload hours, but each professo. received 2 hours, making the average class size only 9.

Similarly, this quarter I am team-teaching "Greek Art, Theatre, and Poetry" with the Theatre Department Chair and an English professor. We have 24 enrolled, so our average class size is a little better. I find that I work almost as hard preparing for this course as I do when I teach a 3 credit on my own, so there is no savings in preparation time. However, it is all worth it for the sake of the students' learning

In reality, most courses will be taught by one professor with specialized knowledge in one field, but he or she can interject segments to reinforce the interrelationship between different disciplines.

A colleague of mine from another institution told how he wanted to approach the topic of urinalysis in an interdisciplinary fashion. At first, I laughed, but then he informed me that urine was collected from soldiers during the Civil War to produce gunpowder. Then I thought of a painting by Jacob van Ruisdael, called "View of Haarlem from the Dunes at Overveen", painted in the 17th Century. (Slide) It shows linen bleaching in the fields - and the Dutch used urine for bleach. So urology linked with American History, Dutch economy, warfare, and painting.

Luckily for me, I teach Art History, which cannot be taught in a silo. My field encompasses archaeology, numismatics, epigraphy, linguistics, history, philosophy, religion, and more. I try to reinforce the relationships, though, and, if the students want to hear more about Dutch economy or modes of transportation in Venice on a particular day - that's fine with me. Never let the curriculum get in the way of learning! My students say that they understand their other courses better due to real world examples they have seen in my class.

Bringing in other disciplines can also help promote other courses. Some history professors borrow slides from me to do art modules from time-to-time, which sparks an interest and sends some students my way!

Let me just share with you one little slice of how science and art can work together. The module that I am presenting can be used in either course. It may spark more of an interest in science due to the

visuals, and it lets art students know that they must be learned in other areas in order to excel in art. Leonardo da Vinci is a great example to use because he was both a scientist and an artist.

I will show you the model in traditional fashion - with an instructor (me) , and also on computer multimedia format.

(Slide - Vitruvian Man)

We possess a record of Leonardo da Vinci's scientific interests and observations due to the notebooks which he began to keep in his early years in Milan, at about the age of thirty. Leonardo kept records of his day-to-day activities in writing (curiously written in a neatly mirrored script), as well as through sketches - sketches of art work, ideas in progress, observations about nature, and innumerable mechanical and scientific drawings. Leonardo's drawings range from early sketchy illustrations of machinery to finished, complex anatomical studies dating from about 1510 and later. Within Leonardo's notebooks are sketches and notes about military engineering, botany, the flight of birds, horses, animal and human dissections, optics, geology, geography, proportions, hydraulics and flight. Leonardo also worked for many years on the Treatise on Painting (left uncompiled at his death). Many of Leonardo's scientific sketches foretold later inventions; for instance, Leonardo almost figured out the human circulatory system. On paper, he invented the airplane*, the helicopter, and, in case of failure of the latter two inventions,* the parachute. Leonardo drew plans for a camera, a functional machine gun and a * (not so functional) military tank. Many of Leonardo's drawings based on dissections could be used in medical textbooks today. His method of presenting multiple views of a body part along with cross-sections is in general use today. * (These drawings were also among the first used to try out computer imaging). Leonardo da Vinci could be called the first medical illustrator. Although early in his career Leonardo's scientific studies may have been intended to advance the realism of his art, as he advanced in age, Leonardo conducted scientific studies more and more for their own sake. Luckily, thousands of pages from Leonardo's notebooks survive; unfortunately much has also been lost.

The influence of Leonardo's scientific studies on his paintings was profound. Some of the paintings directly mirror Leonardo's specific interests of that time, others demonstrate his scientific interests in general. I have chosen six paintings to discuss that span Leonardo's career. They are the

Portrait of Ginevra de' Benci of c. 1474 - 76 in the National Gallery in Washington; The Madonna of the Rocks of 1482 - 83 in the Louvre, Paris; the Portrait of a Lady with an Ermine of c. 1483 - 88 in the Czartoryski Gallery in Cracow, Poland; The Last Supper of c. 1494 - 97 in the refectory of Santa Maria delle Grazie, Milan; the Mona Lisa of c. 1503 in the Louvre; and the Madonna and Child with St. Anne of 1508 - 10 in the Louvre.

In the introduction to his Treatise on Painting Leonardo insists that the painter be universal, neglecting no aspect of nature; that he should be a scientist and understand the inner nature of what he paints; and that he be an expert in mathematics. Leonardo heeded his own advice. He wrote a treatise on perspective (lost), studied nature in all its forms, even to the point of performing dissections for anatomical studies.

When Leonardo painted the Portrait of Ginevra de' Benci *in c. 1474 - 76 he was still a member of Andrea del Verrocchio's shop. At this date, Leonardo was not yet keeping his notebooks with his scientific observations, but we can already see some of the scientific principles at work. Leonardo's knowledge of anatomy is evidenced by the knowledge of bone structure exhibited in Ginevra's face. During this Florentine period Leonardo was not yet dissecting corpses, but he seems to have witnessed a dissection around this time. Leonardo's Treatise on Painting incorporates his studies of science as they relate to the practice of painting. In his treatise, Leonardo writes of the truth of visual information, of moisture in the atmosphere creating different coloristric and perspectival effects, and of the effects of light and shade as relating to structure and color and value contrasts. Leonardo wrote about how a dark background would enhance an illuminated face. On painter's practice he wrote that the artist should set a figure with the "illuminated part against the background" as we see in the Ginevra de' Benci. The sense of atmosphere relates to his study of optics. To my eyes, the beautifully rendered trees suggest that Leonardo was studying trees long before he wrote down his observations on tree growth in his notebooks. The "vortex curls" of Ginevra's hair look ahead to Leonardo's later water studies.*

The Madonna of the Rocks was painted during Leonardo's first Milanese period, commissioned by the Confraternity of the Immaculate Conception in April, 1483. *

The bone structures of the hands and feet of the figures in the Madonna of the Rocks are well observed. This is the time when Leonardo was starting to dissect corpses to enhance the realism of anatomy; he dissected some 25 - 30 corpses of both sexes and various ages. (A brave act, considering the attitude of the Church toward dissections at the time.) Leonardo's knowledge of anatomy is particularly evident in the depiction of the nude infant Christ and St. John.

The atmosphere of the Madonna of the Rocks is so naturalistically rendered that I can almost feel the damp mist enveloping me as I look at the painting. The thick, humid air envelops the figures in a haze; the edges of the figures not sharp, but gently melding into the atmosphere. Leonardo was aware of the presence of water molecules in the air. He wrote "that the brightness of the air is occasioned by the water which has dissolved itself into imperceptible molecules".

The craggy rocks of the landscape of the Madonna display Leonardo's study of things geological, for example, in the accurate representation of the strata of sedimentary rock. Leonardo made studies of rocks and extensive commentary on the discovery of seashells on mountain tops, showing a keen interest in geology. It has been written that the rocks in the landscape of the Madonna of the Rocks are from Leonardo's memories of the quarries of Maiano, but these rocks come not from mere memory, but keen observation and probing study. The plants and flowers are also well observed, down to minute details. Over the years Leonardo studied plant life, and many of his drawings survive. We see the precise observation of a scientist, for instance, *in a drawing of a star of Bethlehem plant, a crowfoot, and a wood anemone by Leonardo. The knowledge gained by such studies enhances the beauty of the Madonna of the Rocks. The effect of Leonardo's scientific studies, rather than making this painting dry and pedantic, enhance the aura of mystery and beauty in Leonardo's Madonna of the Rocks.

One of only three surviving female portraits painted by Leonardo da Vinci is housed in the collection of the Czartoryski Gallery in Cracow, Poland. * The Portrait of a Lady with an Ermine represents Cecilia Gallerani, one of the mistresses of Ludovico Sforza, the Duke of Milan. This oil painting has been dated to c. 1490. This painting's background has been overpainted with black, so its original quality cannot be judged. We may surmise that the original background had a hazy bluish atmosphere (and perhaps landscape elements?). In its present overpainted condition there is a harsh

contrast between the edge of the figure, and the background that is un-Leonardesque. (A detailed study is currently being done on this panel which may result in a cleaning.) The exquisite painting of the woman and the ermine, however, make up for the disappointing background.

The first thing that caught my eye upon viewing the Portrait of a Lady with an Ermine in December, 1992, while it was in the U.S., was the large size of the ermine. Earlier that day I had observed the movements of an active ermine in the mammal house at the National Zoo. The ermine was tiny, between the size of a large mouse and a chipmunk. The ermine held by Cecilia, however, is closer in size to that of a small cat. Martin Kemp also notes the "unusually large scale of the ermine" and compares its exaggerated size to that of babies in Leonardo's Madonna and Child compositions. The ermine was used as a symbolic device to comment on the virtue of the lady and is also a play on her name - galee in Greek means ermine. The ermine itself is an exquisite animal, its size being a harmonious proportion to the woman, its face turned the same direction as Cecilia's, its alertness mirroring her intelligence. The bone structure of the ermine's head is evident, as is that of Cecilia's hand. In 1489 Leonardo was doing studies of bones and the human skull, and studies of animals. A silverpoint of a bear's head also dates to c. 1490. The knowledge that Leonardo gained through his studies is put to use in this portrait. In a poem by Ludovico Sforza's court poet Bernardo Bellincioni, it was written that Leonardo captured Cecilia's "splendid eyes". *Eyes were of extreme importance to Leonardo. He wrote about the importance of eyes and observation extensively in his notebooks. In c. 1489 Leonardo was making studies of eyes, such as those in the Royal Library, Windsor. In c. 1489, in his notes, Leonardo tries to demonstrate the superiority of vision over the other senses. Leonardo even wrote about how difficult it was to dissect a human eye. Out of frustration Leonardo devised a way to dissect an eye while keeping it intact by boiling the eye in egg white! Leonardo, through his experiments, really captured the realism of eyes!

Leonardo was commissioned in 1495 to paint a fresco of the Last Supper, an appropriate theme for the end wall of the refectory for the monks at Santa Maria delle Grazie in Milan. By nature a perfectionist and slow worker on paintings, Leonardo chose not to paint in durable fresco - an unforgiving medium which must be painted quickly. Leonardo, who preferred to work in oils, tried an

experimental method of painting the Last Supper in oils with a ground of gesso, pitch and mastic. This was an experiment that failed. Antonio de Beatis wrote in 1517 that the Last Supper was already beginning to decay. In 1556 Vasari wrote of it as a "mass of blots." To add insult to injury, in 1652, a doorway was cut dead center in the lower portion of the painting. It suffered further damage from humidity and Napoleon's troops when they occupied Milan. The Last Supper is currently being restored under the direction of Dr. Pinan Brambilla Barcilon. Due to its damaged/deteriorated condition, the Last Supper is difficult to evaluate. However, even in its present state, the masterful use of scientific perspective is striking. Leonardo wrote a treatise on perspective, which, unfortunately appears to be lost. Some notes on perspective do survive, however, in Leonardo's notebooks. * In the Last Supper, the vanishing point is directly behind the center of Christ's head, drawing the viewer's eyes to the focal point - a stable, triangular Christ. Christ's face is set apart from the others by a window behind him, with a view to the atmospheric landscape behind. The perspective is so compelling that the room in which Christ and the apostles sit seems to be an extension of the monks' dining hall. The apostles are mathematically arranged into four groups of three. Their anatomy and facial expressions are closely observed from life. The sciences of mathematics, perspective and anatomy work together to create a plausible, harmonious picture of Christ's last Passover meal.

TRANSITION HERE TO THE COMPUTER

Back in Florence in 1503, Leonardo began painting the Mona Lisa. * Vasari tells us that Leonardo painted the portrait of Francesco del Giocondo's wife and left it incomplete after four years' work . It was taken by Leonardo to France, along with the St John the Baptist and Madonna and Child with St. Anne. The Mona Lisa combines Leonardo's study of geology, anatomy, optics (humidity and atmospheric perspective), geometry and perspective.

The exquisite use of chiaroscuro is derived from the studies of skulls * that Leonardo made in c. 1489, when he studied the passage of light over curved surfaces (Clark, 1989, 129). The quality of the

chiaroscuro makes this painting the most three-dimensional looking portrait up until that time. The Mona Lisa seems not a flat, painted image, but rather, a living, breathing being.

Her strength is enhanced by her triangular form; her perfection related to that of the circle, the shape that she forms with her arms.

The hazy, misty atmosphere is well observed, as though Leonardo wants to portray a gentle fog enshrouding the landscape - making it mysterious and unearthly. In 1503 Leonardo was making studies of the effects of meteorologic conditions on the landscape. * The Landscape with a Storm in the Alps reflects Leonardo's meteorological interests at this time. The use of colors in the Mona Lisa binds the woman and landscape together, transferring the mystery of the landscape to the woman and the strength of the woman to the landscape in a symbiotic relationship.

The Mona Lisa shows a perfect melding of science and aesthetics. The landscape is almost an equal partner to the sitter in the Mona Lisa - and the element that sets the mood, as copies by less skillful painters attest.**

In c. 1508 - 13 when Leonardo painted the * Madonna and Child with St. Anne, he expanded on the pyramidal form of the Mona Lisa, intertwining the Madonna, St. Anne, the Christ Child and the lamb into a living pyramid. This work was painted during Leonardo's second Milanese stay, when his scientific studies were becoming more for their own sake than as a means toward perfecting his art. It was during this time that Leonardo did extensive drawings of dissections as scientific studies. Leonardo was trying to figure out the mysteries of human physiology, and of conception, fetal development and birth. The drawing of the Fetus in the Womb * falls into this time period, as does the large drawing of the * Principal Organs and Vascular and Urinogenital Systems of a Woman (c. 1507 - 8) in Windsor Castle. Leonardo's notes of this time deal with studies of generation and writings about the microcosm.

Leonardo's conception of the Madonna and Child with St. Anne * (back) reflects his scientific interests of the time. The painting is a microcosm. Leonardo shows us both sexes - male and female; different ages - infancy, young adulthood, later adulthood; examples from the animal, vegetable and mineral worlds - the lamb, the tree, and the rocky landscape. The Madonna and Child with St. Anne combines geology, geography and geometry. Leonardo does not have to include all kinds of examples of

things. For instance, one tree represents the vegetable world. The painting is a summary of Leonardo's studies.

The idea of generation, of birth, of the mother - child link is also treated in this painting. Leonardo wrote that, while in the womb, the mother and child shared the same soul. The way in which the Virgin encircles the Child with her arms - an extension of womblike protection - relates to Leonardo's studies. The mother/child bond is also seen in the loving gazes exchanged between the Virgin and Child, and from St. Anne to the Virgin and Child - her progeny. The fullness of the Virgin and St. Anne's bodies - although related to the influence of Michelangelo's figure style - also gives a sense of fertility and Leonardo's knowledge of the organs and their workings inside the human body.

I have ended with the Madonna and Child with St. Anne because it seems to embody all of Leonardo's scientific and artistic interests. It is a microcosm of Leonardo's studies.

If a science teacher did not feel comfortable with this sort of material, there is a fun CD-ROM out on Leonardo da Vinci's inventions, with sound, motion, and games.

I wanted to share my Leonardo talk with you in the traditional slide/lecture format. Trading professors from different disciplines to speak in classes is great - but most professors I know have conflicts that preclude that. We can share different interdisciplinary modules, though, via computer technology. I am putting this particular talk into multimedia format; then I can share it on disk with my colleagues. Professors can get together and brainstorm to see where their fields overlap and trade interdisciplinary segments. A recent survey found that 68% of art history students would rather consult a multimedia computer program than a book.

I used Powerpoint, which is relatively simple to use, for my talk. For more complex interactive applications, you may want to use something like Compel. My husband and I are creating a multimedia alternative delivery course called "The Business of Art", cross-listed between MAN and ART, dealing with the unlikely partnership between business and art. Sinclair recently bought a CD-ROM cutter, so we are thinking about how easy it will now be to work up CD-ROM modules and distribute them to the students.

Kenneth Clark, Leonardo da Vinci (last printed in 1989)

Richter, The Notebooks of Leonardo da Vinci

Carlo Pedretti, Leonardo: A Study in Chronology and Style, Los Angeles, 1973.

The 1957 huge book Leonardo da Vinci

Ludwig Heydenreich's 1988 article "Arte e scienza in Leonardo,"

The Unknown Leonardo edited by Ladislao Reti (Maidenhead, England: 1974),

Leonardo on Painting, edited by Martin Kemp (New Haven and London: 1989), and

Ludwig Heidenreich's The Last Supper (New York: 1974).

"Circa 1492: Art in the Age of Exploration" Martin Kemp