Curriculum Objectives and Background

Curriculum Objectives

- Explore how Science, Technology, Engineering and Math (STEM) were developed, altered and utilized by civilization during the medieval period.
- Understand how modern STEM concepts are derived from historical information.
- Experience how the engineering design process works, and how innovation often arises out of need.
- Work collaboratively and experience the processes of science and math through activities, investigations and experimentation.
- Integrate history into the understanding of how science and math developed as disciplines.

Background

The Middle Ages are often considered to be "Dark." This view arose in part because after the fall of the Roman Empire, the lines of communication were cut to a point that information could not easily flow between societies, which in turn lead to a perceived lack of intellectual and economic growth. Society became more fractured, with individual kingdoms fighting for resources, space and control. Amidst this fragmentation, the medieval people traveled, participated in commerce and developed educational systems that are still in use today. Moreover, engineering and technological developments occurred during the 5th through the 14th centuries. The Middle Ages were replete with ingenuity and advancement.

This curriculum explores a sampling of issues, innovations and concepts derived and utilized during the Middle Ages. Students will observe, question, measure, and design. Through these units, students will utilize the observations to determine and understand the origin of modern science and math. Much of the knowledge taught in school today was originally formulated during the Medieval period. For example, developments in algebra and trigonometry became essential for success in travel and trade. Additionally, alchemical experimentation preceded the disciplines that we now recognize as chemistry and toxicology. Throughout this curriculum, students will understand that these small steps in knowledge and technology developed a foundation that later had a large impact on the advancement of society.

MEDIEVAL! STEM Through the Middle Ages is an integrative curriculum. Economics and currency are explored through trade. Agriculture and travel implore the use of mathematics. Technology and application are exercised in alchemy, printing, and food-study units. The progress of STEM concepts are woven through multiple units. By the end of their journey, students will gain an appreciation for the history behind real-world concepts, as well as recognize how an understanding for knowledge is obtained from necessity.

Next Generation Science Standards

MS-LS1-5: *Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.*
MS-LS2-1: *Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms on an ecosystem.*
MS-LS2-4: *Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.*
MS-PS1-2: *Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.*
MS-PS1-3: *Gather and make sense of information to describe that synthetic materials come from natural resources and impact society.*
MS-PS1-4: *Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.*
MS-ETS1-1: *Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.*
MS-ETS1-2: *Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.*
MS-ETS1-3: *Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.*
HS-LS2-2: *Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.*
HS-ETS1-1: *Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.*
HS-ETS1-2: *Design a solution to a complex real-world problem by breaking to down into smaller, more manageable problems that can be solved through engineering.*

Next Generation Science Standards Reference:

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States.* Washington, DC: The National Academies Press.

Science and Engineering Practices

SEP1: *Asking questions and defining problems.*
SEP2: *Developing and using models.*
SEP3: *Planning and carrying out investigations.*
SEP4: *Analyzing and interpreting data.*
SEP5: *Using mathematics and computational thinking.*
SEP6: *Constructing explanations and designing solutions.*
SEP7: *Engaging in argument from evidence.*
SEP8 : *Obtaining, evaluating, and communicating information.*

Mathematics Common Core Standards

5.NF.B.7.C: *Solve real world problems involving long division of unit fractions by non-zero whole numbers and division of whole numbers by unit fractions, e.g. by using visual fraction models and equations to represent the problem.*
6.EE.C.9: *Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation.*
6.RPA.2: *Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship.*
6.RP.A.3: *Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.*
6.RP.A.3.C: *Find a percent of a quantity as a rate per 100; solve problems involving finding the whole, given a part and the percent.*
6.NS.C.5: *Understand that positive and negative numbers are used together to describe quantities having opposite directions or values; use positive and negative numbers to represent quantities in real-world contexts, explaining the meaning of 0 in each situation.*
7.EE.B.4: *Use variables to represent quantities in a real-world or mathematical problem, and construct simple equations and inequalities to solve problems by reasoning about the quantities.*
7.RP.A.2: *Recognize and represent proportional relationships between quantitites.*
7.RP.A.3: *Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.*
7.NS.A.1.D: *Apply properties of operations as strategies to add and subtract rational numbers.*
7.G.B.5: *Use facts about supplementary, complementary, vertical, and adjacent angles in a multi-step problem to write and solve simple equations for an unknown angle in a figure.*

7.SP.C.5: *Understand that the probability of a chance event is a number between 0 and 1 that expresses the likelihood of the event occurring. Larger numbers indicate greater likelihood. A probability neat 0 indicates an unlikely event, a probability around ½ indicates an event that is neither unlikely nor likely, and a probability near 1 indicates a likely event.*

7.SP.C.8.B: *Represent sample spaces for compound events using methods such as organized lists, tables and tree diagrams. For an event described in everyday language (e.g., "rolling double sixes"), identify the outcomes in the sample space which compose the event.*

7.SP.A.1: *Understand that statistics can be used to gain information about a population by examining a sample of the population; generalizations about a population from a sample are valid only if the sample is representative of that population. Understand that random sampling tends to produce representative samples and support valid inferences.*

7.SP.C.7: *Develop a probability model and use it to find probabilities of events. Compare probabilities from a model to observed frequencies; if the agreement is not good, explain possible sources of the discrepancy.*

HSG.SRT.C.8: *Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.*

HSS.IC.B.3: *Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.*

HSS.MD.B.5: *Weigh the possible outcomes of a decision by assigning probabilities to payoff values and finding expected values.*

Common Core Mathematical Practices

MP1: *Make sense of problems and persevere in solving them.*
MP2: *Reason abstractly and quantitatively.*
MP3: *Construct viable arguments and critique the reasoning of others.*
MP4: *Model with mathematics.*
MP5: *Use appropriate tools strategically.*
MP6: *Attend to precision.*
MP7: *Look for and make use of structure.*
MP8: *Look for an express regularity in repeated reasoning.*

Common Core State Standards ELA/Literacy

RI.5.1: *Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the text.*

7.RL.2: *Determine a theme or central idea of a text and analyze its development over the course of the text; provide an objective summary of the text.*

6-8.RH.$: *Determine a theme or central idea of a text and analyze its development over the course of the text: provide an objective summary of the text.*

6-8.RH.7: *Integrate visual information (e.g., in charts, graphs, photographs, vidoes, or maps) with other information in print and digital texts.*

6-8.SL.4: *Present claims and findiings, emphasizing salient points in a focused, coherent manner with relevant evidence, sound valid reasoning, and well-chosen details; use appropriate eye contact, adequate volume, and clear pronunciation.*

6-8.SL.5: *Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.*

6-8.SL.6: *Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.*

6.RI.7: *Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.*

6-8.RST.3: *Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.*

6-8.RST.7: *Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).*

6-8.RST.8: *Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.*

6-8.RST.9: *Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.*

9-10.RST.3: *Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.*

11-12.RST.9: *Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.*

Common Core Mathematics and ELA Standards Reference:

Authors: National Governors Association Center for Best Practices, Council of Chief State School Officers.

Title: Common Core State Standards.

Publisher: National Governors Association Center for best Practices, Council of Chief State School Officers, Washington D.C.

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Unit Summaries and Objectives

Illuminating the Journey

During the Middle Ages, books were rare, expensive, and often decorated with illuminations. In this unit, students will experience the design process used to create illuminated texts as they create a cover for journals that will be used to document their learning through this curriculum.

Objectives:

- Experience the art of creating illuminated letters.
- Create journals to introduce the importance of bookmaking in the Middle Ages, as well as the amount of time and effort placed on the task of creating these books.

You Reap What You Sow

Farming was important to most families during the Middle Ages, as the majority of the population was involved in agriculture for at least part of the year. In this unit the students will investigate the advantages and disadvantages of two- and three-field crop rotation systems, and apply their knowledge in an agricultural design simulation.

Objectives:

- Determine multiple variables that influence farming and crop yield, and predict a system that may assist in the maintenance of the variables.
- Determine the meaning and significance of vocabulary specific to three-field rotation systems (i.e., field rotation system, fallow field, plow, etc.) as they are used in a text, and evaluate how these ideas are related to scientific aspects of agriculture.
- Gain a historical perspective of the significance of agriculture and farming in the Medieval period.
- Engineer a model representative of a three-field rotation system, and evaluate how this model impacts the influence of previously identified farming variables in relation to crop production.
- Implement mathematical concepts (i.e., rates, probability, and number operations) representative of the effects of scientific variables in agriculture to determine overall crop yield.

Churning Through the Years

The lack of refrigeration during the Middle Ages created the necessity for finding other ways to preserve food. Heavily salted butter stored in crocks was one way that milk could be preserved. In this unit, students will explore the physical and chemical science of butter through its production and nutritional analysis.

Objectives:

- Understand how force creates energy that enables molecules to separate during an emulsion, and evaluate how this relates to the physical nature of emulsions.
- Analyze differences in the organic molecules that comprise dairy products.

Say Cheese!

Cheese production was another method for preserving milk. Cheese curds, the first step in making cheese, can be produced through enzyme catalysis and/or acid precipitation. In this unit different methods for producing cheese curds will be explored, as well as the underlying chemistry concepts involved in the process.

Objectives:

- Follow a recipe similar to that used in the Medieval period to produce a fresh cheese product.
- Compare and relate information gained from a modeling activity to experimental data.
- Identify the pH changes that are occurring throughout the process of making cheese.
- Explore the molecular structure of common acids to discover commonalities that may lead to function.
- Determine that acids donate hydrogen ions when placed in water.
- Discover the effect of acid on milk proteins.
- Use a model to predict outcomes of an experiment.

Medieval Measurement

While successfully completing a sea voyage is dependent on so many factors, perhaps the most important is to know your location. During the Middle Ages, mariners used the quadrant and cross staff as navigational tools. Students will build these devices and use them to make measurements of the altitude and/or the angular separation between objects in order to calculate their height.

Objectives:

- Use a quadrant to determine the height of an object.
- Predict and evaluate the accuracy of precision and limitations when using various measurement tools.
- Use a Cross Staff and appropriate mathematical skills to measure the horizontal angular distance and actual horizontal distance between two objects.
- Compare and contrast the method and accuracy of measurements using the Quadrant and the Cross Staff.

Marco Polo: Top Trader

The Travels of Marco Polo inspired generations of merchants and explorers to travel to Asia to seek fame and fortune. In a game inspired by the journeys of Marco Polo, students will flex their mathematical and trading skills on a simulated journey to Asia.

Objectives:

- Calculate the prices of goods by mathematically manipulating various currencies using ratios and proportions.
- Evaluate if the purchase of goods is profitable by successfully calculating currency exchange rates.
- Use knowledge of probability and sample space to determine what options to choose.
- Become familiar with the geography of the Silk Road and the patterns of trade for luxury goods in the Middle Ages.

On the Verge of Time

Measuring the passage of time plays an important role in our lives. The people who lived during the Middle Ages wanted to measure time as well, but were limited by the technology available. After exploring the ways that time was measured during the medieval period, students will use the engineering design cycle to build and improve a clock.

Objectives:

- Determine why time-keeping devices were necessary during the Medieval period, and make connections to how they are used in modern day society.
- Collect and evaluate the use of early time-keeping devices such as the sundial, clepsydra, hourglass, and mechanical clock.
- Use the engineering design cycle to construct a verge and foliot clock (mechanical clock) that executes a constant rate of time. Students will investigate the role that weight and intentional design have on the function of the clock.

Rags to Paper

During the Middle Ages, writing was initially done on vellum made from animal skins. In subsequent years, paper made from linen and cotton was developed using a process that was cheaper and more efficient than the manufacturing of vellum. However, use of paper did not become popular until the late Middle Ages. In this unit, students will make their own cotton paper and discover the importance of the various materials used.

Objectives:

- Compress separate, natural fibers into a unified material to form paper.
- Discover that water is a necessary component to the paper-making process.
- Relate the properties of water to its necessary use in making rag paper.
- Experience medieval technology through the process of paper-making.
- Discover that useable paper can be produced through the use of a variety of techniques and materials.
- Compare different paper sizing techniques and materials, and relate the importance of this procedure to the paper-making process.

We Are All Made of Stars

The alchemists of the Middle Ages developed chemistry techniques and discovered practical uses for chemistry. In this unit, students will be introduced to the medieval study of Alchemy and discuss the possibility of transmutation.

Objectives:

- Understand that one of the main goals of the medieval alchemist was to transmute base metals to gold.
- Compare the work that alchemists conducted to modern science.
- Discover that changes in the atomic nucleus are necessary to transmute metals.

Ashes, Ashes, We All Fall Down

The Black Death was a one of the most widespread and deadly epidemics in history. Through simulations, students will investigate how death, immunity, and quarantine affect the spread of a disease though a population, and draw parallels between how epidemics affected populations in the medieval period as well as the preventive measures and modern medical interventions available today.

Objectives:

- Observe and evaluate the spread of an epidemic by participating in a kinesthetic simulation.
- Collect and analyze data representative of the impact of the Black Death on medieval town populations. Students will determine how death, immunity, quarantine, and the spread of the disease affected population.

Dose

A split amongst alchemists began to occur late in the middle ages. Some alchemists, such as Paracelsus, firmly asserted that alchemy should not be concerned with transmutation, but with medicine. Students will create a series of dilutions of alcohol that act as dosages to determine the LD_{50} (lethal dose – dose at which 50% of the population being studied fails to survive) for radish seeds.

Objectives:

- Determine the specific dosage of isopropyl alcohol that leads to a 50% rate of failure to grow for radish seeds in an experimental situation.
- Relate the aforementioned dosage experiment to the work of Paracelsus and to the beginnings of the field of toxicology.

So Much Depends Upon Printing

The invention of the printing press is considered by most historians to be the invention that defines the end of the medieval period and the beginning of the Renaissance. In order to invent moveable type, Gutenberg had many obstacles to overcome. In this unit, students will experience the difficulty of sharing information through writing and block printing. They will then explore one of Gutenberg's technical challenges—finding a reliable way to make moveable type. They will then relate their learning to the ways that information is transmitted now.

Objectives:

- Relate the importance of the development of the printing press to the difficulty of mass producing print items manually, or through block printing.
- Analyze and define aspects of the design process that Gutenberg employed in developing the printing press.
- Explore the design problem of casting molds and using workable materials in developing typeface.

Everything is Illuminated

The culmination of the entire curriculum, through an exploration of their journals, this unit allows time for the students to reflect upon their journey through STEM in the Middle Ages.

Objectives:

- Collaboratively reflect on individual experiences with those of others through presentations and discussions of their journals.
- Investigate the relationship between Medieval and modern day technologies and applications as it applies to the concepts learned throughout the curriculum.
- Review and analyze what was learned through the activities in the curriculum as it relates to science, technology, engineering and mathematics (STEM).