Invention Project Middle School Program Curricula Alignment with STEM Content & 21st Century Skills

	STEM Content				21st Century Learning Outcomes: "Learning and Innovation Skills"[1]								
					Creativity & Innovation			Critical Thinking & Problem Solving				Communication & Collaboration	
	Science	Technology	Engineering	Mathematics	Think Creatively	Work Creatively with Others	Implement Innovations	Reason Effectively	Use System Thinking	Make Judgments & Decisions	Solve Problems	Communicate Clearly	Collaborate with Others
Invention Project I™	x	x	x	x	x	x	x	x	x	x	x	x	x

[1]Partnership for 21st Century Skills. (2009, December). P21 Framework definitions document. Retrieved July 29, 2010 from http://p21.org/documents/P21_Framework_Definitions.pdf.

Invention Project®

THE INVENTION PROJECT™ ALIGNMENT WITH STEM CONTENT & 21ST CENTURY SKILLS

KEY CONCEPTS

- Transportation is the movement of people, animals, or goods from one place to another.
- There are many areas of vehicle design where innovation can be applied.
- Business is practicing and engaging in commerce.
- Entrepreneurship encompasses invention, innovation, economics, business, and marketing principles.
- Profit is the amount of money that business or individuals earn after they deduct their expenses.
- Demand is the number of products that consumers want to buy.
- Design engineering is developing practical solutions to real-world problems, using insights from all of the fields of engineering.
- Design thinking is a discipline that uses a designer's methods to match people's needs with what is technologically possible and what has market value.
- Potential energy is stored energy, and kinetic energy is energy in motion.
- Art sometimes requires science, and science can be brought to life through art.
- Kinetic sculptures often work by making use of mechanical engineering and simple machines.
- Leadership needs to be practiced before it can be mastered.
- Personalized technology innovations are reshaping people's lifestyles.
- Circuits play a key role in personalized technology.
- Innovation is developing and applying new ideas that have value to people.
- Design engineering is developing practical solutions to real-world problems, using insights from all of the fields of engineering.
- Design thinking is a discipline that uses a designer's methods to match people's needs with what is technologically possible and what has market value.
- As new technology is developed, it opens the door for new innovations.

OBJECTIVES

- Discuss various types of transportation.
- Design the transportation of the future.
- Practice business and entrepreneurship as well as explore profits and losses.
- Utilize design engineering.
- Employ design thinking.
- Explore the role of simple machines and motion in sculptures and installations.
- Explore the combination of art and science through kinetic sculptures and chain reaction contraptions.
- Design their own moving sculptures or chain reaction installations.
- Explore leadership.
- Employ design engineering to modify sunglasses to have innovative features.
- Practice communication as they navigate a course.
- Explore the concept of wearable technology.
- Explore the role of circuits in wearable technology.
- Design their own wearable or personalized technology items.
- Employ engineering and design to create innovative new products.
- Use technology in practical ways.
- Practice business principles.
- Use design engineering to create a health and wellness video game.
- Learn that Venture capitalists can provide capital to startup companies and small businesses with high-growth potential in exchange for an ownership stake in the firm - with an expectation that they will be able to recoup their original investment, and potentially earn up to 10 times or 100 times as much as they had originally invested after a 3-5 year time period.
- Collaborate to make a business decision about investments.
- Explore the role that simple circuits and robotics play in the world.

THE INVENTION PROJECT I™ ALIGNMENT WITH STEM CONTENT & 21ST CENTURY SKILLS

KEY CONCEPTS

- Exposure to a variety of business careers and skills builds awareness of possibilities for future endeavors for Innovators.
- Venture capitalists give investment money to start-up companies or small businesses, anticipating the long-term growth potential of the start-up or small business.
- An understanding of medicine and biology can help inventors make innovations that improve the health and wellness of people.
- Circuits are key to the functioning of robots.
- Robotics is a branch of technology that deals with the design, building, operating, and use of robots.
- Counterbalance and vibration play a key role in the movement of motor-based Mini-Bots.
- Robotics requires an understanding of programming.
- Engineering is employed in robotics.
- Design requires an understanding of the intended user and allows a designer to better employ function.
- Many jobs require knowledge and experience in STEM.
- Creativity involves the novel (original) production of ideas to solving a challenge.
- Innovation is the process of introducing new ideas, products, systems, and processes.
- Media is a general term for mass communication.
- Technological advances are changing the way that people interact with media.
- Market research is observing and researching the way products are used by consumers so that information can be gathered and used.
- Observation is watching and listening to gather useful information about a product.
- Application is important in design, and it takes into consideration how products will be used.
- Adaptive innovation is an important kind of invention that allows an inventor to make changes to an original invention in such a way that makes it a new innovation.

OBJECTIVES

- Design their own Mini-Bots and have them interact.
- Use programming to make a robot work.
- Employ engineering to design a course for a robot.
- Explore how teams use varied and diverse careers.
- Be introduced to National Inventors Hall of Fame Inductee Garrett Brown and his concept of looking for "what is missing."
- Explore their ideas for inventions that are missing in their lives or the world and make prototypes.
- Explore the role of media in their lives.
- Design prototypes of media technology and/or media platforms for the future.
- Apply market research when making a new product.
- Explore adaptive innovation.
- Employ design principles by creating new features for earbuds.
- Explore the components of a game that have design possibilities.
- Design and play their own games.
- Explore the concept of speed-to-market.
- Use mathematics to calculate profit.
- Experience rapid prototyping.
- Explore their ideas around day-to-day life tasks that could be improved or enhanced through invention.
- Design prototypes of life hacks.
- Explore the use of technology for life-hack prototypes.
- Tinker and explore to better understand invention.
- Explore what makes a great space.
- Design their own spaces.
- Market their product.
- Use mathematics to create a budget.
- Create advertisements.
- Explore their own ideas to enhance, improve, or even save lives.
- Meet Collegiate Inventors who are using biomedical engineering to invent devices that are improving healthcare.

THE INVENTION PROJECT™ ALIGNMENT WITH STEM CONTENT & 21ST CENTURY SKILLS

KEY CONCEPTS

- Game design employs a high degree of creativity related to various components, such as strategy, point structure, aesthetic design, and overall goals.
- Communities of people are sometimes built around various types of games.
- Gamification is the use of game thinking and game mechanics in nongame scenarios (e.g., solving problems) to engage people.
- Speed-to-market is a business principle that measures how quickly a company can create a product, manufacture it, and market it, making it ready for purchasing.
- Quality control is a business measurement that ensures products make it to consumers with little to no errors.
- Profit is the amount of money that businesses or individuals earn after they deduct their expenses.
- In business, typically the middleman buys products from a producer and sells them to consumers for more money than they originally cost, thereby making a profit.
- Rapid prototyping is the process of quickly making a prototype so that stakeholders, such as investors and consumers, can provide useful feedback, which can be used to inform other designs, reducing overall development time and increasing the speed-to-market.
- Inventions are sometimes life saving. They can also be as simple as making life easier or more enjoyable or just giving day-to-day tasks a little twist.
- Looking at things in a new way is a creative thinking skill that has led to many inventors' successes.
- Many challenges can be solved by applying creativity and ingenuity and upcycling common materials.
- Innovation is developing and applying new ideas that have value to people.
- Design engineering is developing practical solutions to real-world problems, using insights from all of the fields of engineering.

OBJECTIVES

- Explore the use of technology for health and wellness invention prototypes.
- Communicate and collaborate within a team.
- Employ STEM.
- Explore angel investing.

THE INVENTION PROJECT™ ALIGNMENT WITH STEM CONTENT & 21ST CENTURY SKILLS

KEY CONCEPTS

- Design thinking is a discipline that uses a designer's methods to match people's needs with what is technologically possible and what has market value.
- Tinkering is the art of exploring, investigating, taking risks, and experimenting with materials to explore possibilities.
- Designing spaces taps into a wide variety of skills and trades.
- A spatial relationship refers to the way an object relates to another reference object within a given space.
- Marketing is multifaceted information distribution about a product to the consumer.
- Social media is a tool that is used for marketing.
- Budget is a balance of income and expenses over a period of time.
- Advertisements promote a product and are used in marketing.
- Biomedical engineering is a field that applies engineering principles and design concepts to medicine and biology.
- Using biomedical engineering principles to invent often leads to improved healthcare innovations.
- Advanced technologies are changing the way that people engage with their health and wellness.
- There is a connection between science, technology, and the invention process.
- Engineers, designers, and inventors all use creative problem solving.
- Inventions can be adapted and modified.
- An angel investor gives money to a company, entrepreneur, or inventor to help the company.

COMMON CORE STATE STANDARD ALIGNMENT TO THE INVENTION PROJECT I™

CCSS.ELA-LITERACY.RI7.6
Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as inwords to develop a coherent understanding of a topic or issue.

CCSS.ELA-LITERACY.W2.6
Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant content.

a. Introduce a topic; organize ideas, concepts, and information, using strategies such as definition, classification, comparison/contrast, and cause/effect; include formatting (e.g., headings), graphics (e.g., charts, tables), and multimedia when useful to aiding comprehension.

d. Use precise language and domain-specific vocabulary to inform about or explain the topic.

CCSS.ELA-LITERACY.W6.6-8
Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas efficiently as well as to interact and collaborate with others.

CCSS.ELA-LITERACY.W10.6-8
Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

CCSS.ELA-LITERACY.SL1.6
Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.

a. Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.

b. Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.

c. Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.

d. Review the key ideas expressed and demonstrate understanding of multiple perspectives through reflection and paraphrasing.

CCSS.ELA-LITERACY.SL2.7
Analyze the main ideas and supporting details presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how the ideas clarify a topic, text, or issue under study.

CCSS.ELA-LITERACY.SL3.7
Delineate a speaker's argument and specific claims, evaluating the soundness of the reasoning and the relevance and sufficiency of the evidence.

CCSS.ELA-LITERACY.SL4.6-8
Present claims and findings, 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.

CCSS.ELA-LITERACY.SL5.6-8
Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest.

CCSS.ELA-LITERACY.SL6.6-8
Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate. (See grade 8 Language standards 1 and 3 on page 53 for specific expectations.)

CCSS.ELA-LITERACY.L3.6-8
Use knowledge of language and its conventions when writing, speaking, reading, or listening.

a. Vary sentence patterns for meaning, reader/listener interest, and style.

b. Maintain consistency in style and tone.

CCSS.ELA-LITERACY.L4.6
Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on grade 6 reading and content, choosing flexibly from a range of strategies.

a. Use context (e.g., the overall meaning of a sentence or paragraph; a word's position or function in a sentence) as a clue to the meaning of a word or phrase.

CCSS.ELA-LITERACY.L5.6
Demonstrate understanding of figurative language, word relationships, and nuances in word meanings.

a. Interpret figures of speech (e.g., personification) in context.

b. Use the relationship between particular words (e.g., cause/effect, part/whole, item/category) to better understand each of the words.

c. Distinguish among the connotations (associations) of words with similar denotations (definitions) (e.g., stingy, scrimping, economical, unwasteful, thrifty).

CCSS.ELA-LITERACY.L6.6-8
Acquire and use accurately grade-appropriate general academic and domain-specific words and phrases; gather vocabulary knowledge when considering a word or phrase important to comprehension or expression.

CCSS.ELA-LITERACY.RH7.6-8
Integrate visual information (e.g., in charts, graphs, photographs, videos, or maps) with other information in print and digital texts.

CCSS.ELA-LITERACY.RH8.6-8
Distinguish among fact, opinion, and reasoned judgment in a text.

CCSS.ELA-LITERACY.RST1.6-8
Cite specific textual evidence to support analysis of science and technical texts.

CCSS.ELA-LITERACY.RST2.6-8
Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.

CCSS.ELA-LITERACY.RST3.6-8
Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.

CCSS.ELA-LITERACY.RST4.6-8

Determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context relevant to grades 6–8 texts and topics.

CCSS.ELA-LITERACY.RST6.6-8

Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.

CCSS.ELA-LITERACY.RST7.6-8

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).

CCSS.ELA-LITERACY.RST8.6-8

Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.

CCSS.ELA-LITERACY.RST9.6-8

Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.

CCSS.ELA-LITERACY.WHST1.6-8

Write arguments focused on discipline-specific content.

a. Introduce claim(s) about a topic or issue, acknowledge and distinguish the claim(s) from alternate or opposing claims, and organize the reasons and evidence logically.

c. Use words, phrases, and clauses to create cohesion and clarify the relationships among claim(s), counterclaims, reasons, and evidence.

d. Establish and maintain a formal style.

e. Provide a concluding statement or section that follows from and supports the argument presented.

CCSS.ELA-LITERACY.WHST2.6-8

Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.

d. Use precise language and domain-specific vocabulary to inform about or explain the topic.

e. Establish and maintain a formal style and objective tone.

f. Provide a concluding statement or section that follows from and supports the information or explanation presented.

CCSS.ELA-LITERACY.WHST6.6-8

Use technology, including the Internet, to produce and publish writing and present the relationships between information and ideas clearly and efficiently.

CCSS.ELA-LITERACY.WHST7.6-8

Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.

CCSS.ELA-LITERACY.WHST9.6-8

Draw evidence from informational texts to support analysis reflection, and research.

CCSS.ELA-LITERACY.WHST10.6-8

Write routinely over extended time frames (time for reflection and revision) and shorter time range of discipline-specific tasks, purposes, and audiences.

COMMON CORE STANDARDS FOR MATHEMATICS

CCSS.MATH.6.RP.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.

c. Find a percent of a quantity as a rate per 100 (e.g., 30% of a quantity means 30/100 times the quantity); solve problems involving finding the whole, given a part and the percent.

CCSS.MATH.7.RP.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.

CCSS.MATH.7.NS.3

Solve real-world and mathematical problems involving the four operations with rational numbers. (Computations with rational numbers extend the rules for manipulating fractions to complex fractions.)

NEXT GENERATION SCIENCE STANDARDS

MS-PS2 MOTION AND STABILITY: FORCES AND INTERACTIONS

Students who demonstrate understanding can:

MS-PS2-1.

Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.* [Clarification Statement: Examples of practical problems could include the impact of collisions between two cars, between a car and stationary objects, and between a meteor and a space vehicle.] [Assessment Boundary: Assessment is limited to vertical or horizontal interactions in one dimension.]

MS-PS2-2.

Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object. [Clarification Statement: Emphasis is on balanced (Newton's First Law) and unbalanced forces in a system, qualitative comparisons of forces, mass and changes in motion (Newton's Second Law), frame of reference, and specification of units.] [Assessment Boundary: Assessment is limited to forces and changes in motion in one-dimension in an inertial reference frame and to change in one variable at a time. Assessment does not include the use of trigonometry.]

MS-PS2-3.

Ask questions about data to determine the factors that affect the strength of electric and magnetic forces. [Clarification Statement: Examples of devices that use electric and magnetic forces could include electromagnets, electric motors, or generators. Examples of data could include the effect of the number of turns of wire on the strength of an electromagnet, or the effect of increasing the number or strength of magnets on the speed of an electric motor.] [Assessment Boundary: Assessment about questions that require quantitative answers is limited to proportional reasoning and algebraic thinking.] The performance expectations above were developed using the following elements from the NRC document A Framework for K-12 Science Education.

PS2.A: FORCES AND MOTION

- For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law). (MS-PS2-1)
- The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion. (MS-PS2-2)
- All positions of objects and the directions of forces and motions must be described in an arbitrarily chosen reference frame and arbitrarily chosen units of size. In order to share information with other people, these choices must also be shared. (MS-PS2-2)

CAUSE AND EFFECT

- Cause and effect relationships may be used to predict phenomena in natural or designed systems. (MS-PS2-3), (MS-PS2-5)

SYSTEMS AND SYSTEM MODELS

- Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems. (MS-PS2-1), (MS-PS2-4)

STABILITY AND CHANGE

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales. (MS-PS2-2)

INFLUENCE OF SCIENCE, ENGINEERING, AND TECHNOLOGY ON SOCIETY AND THE NATURAL WORLD

- The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-PS2-1)

ASKING QUESTIONS AND DEFINING PROBLEMS

Asking questions and defining problems in grades 6–8 builds from grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles. (MS-PS2-3)

PLANNING AND CARRYING OUT INVESTIGATIONS

Planning and carrying out investigations to answer questions or test solutions to problems in 6–8 builds on K–5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or design solutions.

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. (MS-PS2-2)
- Conduct an investigation and evaluate the experimental design to produce data to serve as the basis for evidence that can meet the goals of the investigation. (MS-PS2-5)

CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas or principles to design an object, tool, process or system. (MS-PS2-1)

ENGAGING IN ARGUMENT FROM EVIDENCE

Engaging in argument from evidence in 6–8 builds from K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

- Construct and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem. (MS-PS2-4)

SCIENTIFIC KNOWLEDGE IS BASED ON EMPIRICAL EVIDENCE

- Science knowledge is based upon logical and conceptual connections between evidence and explanations. (MS-PS2-2), (MS-PS2-4)

MS-PS3 ENERGY

Students who demonstrate understanding can:

MS-PS3-1.

Construct and interpret graphical displays of data to describe the relationships of kinetic energy to the mass of an object and to the speed of an object. [Clarification Statement: Emphasis is on descriptive relationships between kinetic energy and mass separately from kinetic energy and speed. Examples could include riding a bicycle at different speeds, rolling different sizes of rocks downhill, and getting hit by a wiffle ball versus a tennis ball.]

MS-PS3-2.

Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system. [Clarification Statement: Emphasis is on relative amounts of potential energy, not on calculations of potential energy. Examples of objects within systems interacting at varying distances could include: the Earth and either a roller coaster cart at varying positions on a hill or objects at varying heights on shelves, changing the direction/orientation of a magnet, and a balloon with static electrical charge being brought closer to a classmate's hair. Examples of models could include representations, diagrams, pictures, and written descriptions of systems.] [Assessment Boundary: Assessment is limited to two objects and electric, magnetic, and gravitational interactions.]

MS-PS3-5.

Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object. [Clarification Statement: Examples of empirical evidence used in arguments could include an inventory or other representation of the energy before and after the transfer in the form of temperature changes or motion of object.] [Assessment Boundary: Assessment does not include calculations of energy.] The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

PS3.A: DEFINITIONS OF ENERGY

- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1)
- A system of objects may also contain stored (potential) energy, depending on their relative positions. (MS-PS3-2)

PS3.B: CONSERVATION OF ENERGY AND ENERGY TRANSFER

- When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)

PS3.C: RELATIONSHIP BETWEEN ENERGY AND FORCES

- When two objects interact, each one exerts a force on the other that can cause energy to be transferred to or from the object. (MS-PS3-2)

ETS1.A: DEFINING AND DELIMITING AN ENGINEERING PROBLEM

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that is likely to limit possible solutions. (secondary to MS-PS3-3)

ETS1.B: DEVELOPING POSSIBLE SOLUTIONS

- A solution needs to be tested, and then modified on the basis of the test results in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet criteria and constraints of a problem. (secondary to MS-PS3-3)

SYSTEMS AND SYSTEM MODELS

- Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2)

ENERGY AND MATTER

- Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3-5)
- The transfer of energy can be tracked as energy flows through a designed or natural system. (MS-PS3-3)

DEVELOPING AND USING MODELS

Modeling in 6–8 builds on K–5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to describe unobservable mechanisms. (MS-PS3-2)

CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific ideas or principles to design, construct, and test a design of an object, tool, process or system. (MS-PS3-3)

ENGAGING IN ARGUMENT FROM EVIDENCE

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed worlds.

- Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3-5)

SCIENTIFIC KNOWLEDGE IS BASED ON EMPIRICAL EVIDENCE

- Science knowledge is based upon logical and conceptual connections between evidence and explanations (MS-PS3-4), (MS-PS3-5)

MS-ETS1 ENGINEERING DESIGN

Students who demonstrate understanding can:

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.

MS-ETS1-4

Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education.*

ETS1.A: DEFINING AND DELIMITING ENGINEERING PROBLEMS

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

ETS1.B: DEVELOPING POSSIBLE SOLUTIONS

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: OPTIMIZING THE DESIGN SOLUTION

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

INFLUENCE OF SCIENCE, ENGINEERING, AND TECHNOLOGY ON SOCIETY AND THE NATURAL WORLD

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1)
- The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

ASKING QUESTIONS AND DEFINING PROBLEMS

Asking questions and defining problems in grades 6–8 builds on grades K–5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)

DEVELOPING AND USING MODELS

Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.

- Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs. (MS-ETS1-4)

ANALYZING AND INTERPRETING DATA

Analyzing data in 6–8 builds on K–5 experiences and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.

- Analyze and interpret data to determine similarities and differences in findings. (MS-ETS1-3)

ENGAGING IN ARGUMENT FROM EVIDENCE

Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world.

- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)