Item Name:	Building A Prototype: Thermal Energy Transfer
Item Type:	Complex Project
Subject and/or Course:	Science, Physical Science or Engineering, Grade 6
Common Core Standards:	**CCSS** • CCSS.ELA-Literacy.RST.6.1 Cite textual evidence to support analysis… • CCSS.ELA-Literacy.RST.6.7 Integrate information presented… • CCSS.ELA-Literacy.WHST.6.4 Produce clear and coherent writing… • CCSS.ELA-Literacy.WHST.6.5 With some guidance and support… **NGSS Science and Engineering Practices** • MS-LS1-1 Conduct an investigation to produce data… • MS-LS1-5 Construct a scientific explanation… • MS-ESS3-3 Apply scientific principles to design an object… • MS-PS3-3 Apply scientific ideas or principles to design… **NGSS Disciplinary Core Ideas** PS3.A Definitions of Energy • The term "heat" as used in everyday language… • The temperature of a system is proportional… • The total thermal energy (sometimes called the total internal energy)… • MS-PS3-4 The amount of energy transfer needed… • MS-PS3-3 Energy is spontaneously transferred… • MS-PS3-3 A solution needs to be tested… **NGSS Cross-Cutting Concepts** • MS-PS3-3 The transfer of energy can be tracked as energy flows… • MS-PS3-5 Energy may take different forms… **NGSS Performance Expectation:** • MS-PS3-3 Apply scientific principles to design, construct, and test… • MS-PS3-4 Plan an investigation to determine the relationships… • MS-PS3-5 Construct, use, and present arguments…
Developer/Source:	Stanford Center for Assessment, Learning, and Equity (SCALE) funded by the George Lucas Education Foundation
Item Features:	Administration: Complex Project Length of time for response: 6 to 8 weeks for whole unit Method of scoring: Analytic rubric (SCALE Scientific Practices Rubric) Opportunity for student collaboration: Daily Opportunity for teacher feedback and revision: Once a week

TET Thermal Energy Transfer INC

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To: Students of (SCHOOL NAME)
From: Marie Watt, CTO
CC: (TEACHER NAME)
Date: Tuesday, July 29, 2014
Re: Call for Innovative Designs

As the President of Thermal Energy Transfer (TET), I am pleased to hear that your team of young scientists and engineers is interested in helping our company design solutions for some real-world problems.

Several clients have come to TET, asking us to help them design special devices in the area of thermal energy. Now, we are asking for your help to make this possible! Both we at TET and our clients are interested in seeing what innovative and groundbreaking ideas your team will come up with in the area of thermal energy. We are asking you to choose from one of the client requests listed on the next page. The goal of your group will be to create a device that will either maximize or minimize thermal energy transfer.

As part of this work, your team will need to **design and construct a model (prototype)** for the client. You will need to **test the prototype**, collect **data,** and **analyze** how well your prototype works. You will also need to make **changes** to improve the original design.

At TET we want to protect all new ideas we receive from our skilled engineers. In order to do this, we require each team **to write a patent application** to accompany the prototypes. The patent application must include:

1. **The title of the invention**
2. **Abstract** *(One paragraph summary of the patent application)*
3. **Background of the invention** *(An explanation of thermal energy, temperature, kinetic energy, and transfer of energy, and how they relate to your device)*
4. **Detailed description of the invention: the design and the revision process**
5. **Labeled drawings of original design and revised designs, including dimensions**
6. **Evidence, Claim, and Justification** (*Analyze how well your prototype works)*

In addition, your team will be required to give an **oral presentation** to share your design with the clients. The presentation should include:

- Demonstration of the prototype
- Description of thermal energy transfer in your device
- Analysis of the data from your investigation.

We look forward to being impressed by your design and presentation. The project deadline is (INSERT DATE). Sincerely,

Marie Watt

Marie Watt, President of TET

TET Thermal Energy Transfer, INC Client List

1. **Cocina del Sol: A Latin American, eco-friendly food truck company**
    - Needs: A device to bake their specialty cookies (Spicy Mayan Chocolate Chip) using the power from the sun

2. **Salmon Conservation Foundation**
    - Needs: A design for gloves to use for their researchers in Alaska who work with salmon in very cold streams and rivers. The stream temperatures range from 8-14 °C. Human body temperature is 37°C.

3. **Only Have Ice for You: Ice delivery company, specializing in ice for ice carving competitions**
    - Needs: A device that will keep a block of their ice (200 cm tall X 130 cm wide X 65 cm thick) from melting
      (note: given the large size of their ice block, the prototype must be a scaled model of the actual device)

4. **Backcountry Expeditions: An adventure travel company**
    - Needs: A hut to use along snowy winter backpacking trails; the hut needs to be insulated in order to store food/supplies and large enough to accommodate backpackers for the night if needed.
      (Note: given the large size of an actual hut, the prototype must be a scaled model)

5. **Clean Water for All: Non-profit organization focused on providing drinkable water for all**
    - Needs: A device that can be used to boil river water to kill bacteria

SCIENTIFIC PRACTICES RUBRIC

INITIATING THE INQUIRY

What is the evidence that the student can formulate questions and models that can be explored by scientific investigations as well as articulate a testable hypothesis?

SCORING DOMAIN	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
ASKING QUESTIONS	• Formulates a general scientific question • Provides limited or irrelevant content information		• Formulates a specific scientific question • Provides general content information that is related to the question		• Formulates a specific and empirically testable scientific question • Provides specific and relevant content information to lend support for the question		• Formulates a specific, testable, and challenging scientific question • Provides specific and relevant content information to provide insight into the inquiry
DEVELOPING AND USING MODELS	• Drawings, diagrams, or models relevant to the investigation includes major conceptual or factual errors, or are missing • Discussion on limitations or precision of model as a representation of the system or process is flawed or missing		• Constructs generally accurate drawings, diagrams, or models to represent the process or system to be investigated • Makes note of limitations or precision of model as a representation of the system or process		• Constructs accurate drawings, diagrams, or models to represent the process or system to be investigated • Explains limitations and precision of model as a representation of the system or process		• Constructs accurate and precise drawings, diagrams, or models to represent the process or system to be investigated and provides an explanation of the representation • Explains limitations and precision of model as a representation of the system or process and discusses how the model might be improved
STATING A HYPOTHESIS	• Articulates a prediction that has limited relationship to the question under investigation		• Articulates a relevant prediction of the expected results, but variables are unclearly stated		• Articulates a hypothesis about the investigated question, with a basic and accurate description of the variables ("if.. then…")		• Articulates a hypothesis about the investigated question, with accurate and specific explanation of the relationship between variables ("if.. then…because")

PLANNING AND CARRYING OUT INVESTIGATIONS *What is the evidence that the student can design and perform investigations to explore natural phenomena?*							
SCORING DOMAIN	**EMERGING**	**E/D**	**DEVELOPING**	**D/P**	**PROFICIENT**	**P/A**	**ADVANCED**
DESIGNING THE INVESTIGATION	• Experimental design is not aligned to the testable question • Discussion of how the model can guide or inform the design or an aspect of the design is missing		• Experimental design is related but not explicitly aligned to testable question • States in general terms how model was used to guide, inform, or test the design or an aspect of the design		• Aligns experimental design with testable question • Explains how model was used to guide, inform, or test the design, or an aspect of the design		• Explains the alignment between the experimental design and the testable question • Explains how model was used to guide, inform, or test the design, or an aspect of the design
IDENTIFYING VARIABLES	• Identifies variables of investigation but confuses dependent and independent variables • Makes no connection between the plan and variables		• Accurately identifies the relevant independent and dependent variables • States how the plan will control relevant independent OR dependent variables		• Accurately identifies and explains why the variables are dependent and independent in the investigation • Explains how the plan will control relevant independent AND dependent variables		• Accurately identifies and explains why the variables are dependent and independent in the investigation and identifies possible confounding variables and effects and tries to control for them • Explains how the plan will control relevant independent and dependent variables, and the possible confounding variables or effects
DEVELOPING PROCEDURES	• Includes vague or incomplete lab procedures; or uses inappropriate tools, instruments, or types of measurement • Amount of data to be collected is omitted		• Describes lab procedures including tools/ instruments used, but is not clear or detailed enough to be replicated • States the amount of data to be collected with no rationale		• Describes detailed, clear, and replicable lab procedures including tools /instruments and types of measurements gathered • Provides a rationale for the appropriate amount of data needed to produce reliable measurements		• Describes detailed, clear, and replicable lab procedures including rationale for using the tools /instruments and types of measurements gathered • Provides a rationale for the appropriate amount of data needed to produce reliable measurements
COLLECTING DATA	• Gathers data from a single trial of the experiment • Limitations or precision of data are not mentioned		• Gathers data from several repetitions of the experiment that are clearly outside the reasonable range • Mentions limitation or precision of data		• Gathers data from several repetitions of the experiment that are not consistent within a reasonable range • Explains limitation or precision of data		• Gathers data from several repetitions of the experiment that are consistent within a reasonable range • Explains limitation or precision of data and impact on conclusions

REPRESENTING, ANALYZING, AND INTERPRETING THE DATA

What is the evidence that the student can organize, analyze, and interpret the data?

SCORING DOMAIN	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
REPRESENTING THE DATA *Accurately labeled includes title, column titles, description of units, proper intervals.*	• Uses spreadsheets, data tables, charts, or graphs but does not accurately summarize and/or display data • Constructs spreadsheets, data tables, charts, or graphs with major omissions or errors		• Uses spreadsheets, data tables, charts, or graphs to accurately summarize and display data; format does not allow for examining the relationships between variables • Constructs spreadsheets, data tables, charts, or graphs with minor errors (e.g., missing labels)		• Uses spreadsheets, data tables, charts, or graphs to accurately summarize and display data to examine relationships between variables • Constructs accurately labeled and appropriately organized spreadsheets, data tables, charts, or graphs		• Uses multiple methods (spreadsheets, data tables, charts, graphs) to accurately summarize and display data to examine relationships between variables • Constructs accurately labeled and expertly organized spreadsheets, data tables, charts, or graphs
USING MATHEMATICS AND COMPUTATION-AL THINKING	• Expresses relationships and quantities (units) using mathematical conventions with major errors • Evaluation of whether the mathematical computation results "make sense" is omitted		• Expresses relationships and quantities (units) using mathematical conventions with minor errors • Makes note of whether the mathematical computation results "makes sense" without reference to the expected outcome		• Accurately expresses relationships and quantities (units) using appropriate mathematical conventions • Explains whether the mathematical/computation results "make sense" in relationship to the expected outcome		• Accurately and consistently expresses relationships and quantities (units) using appropriate mathematical conventions • Consistently evaluates whether the mathematical/computation results "make sense" in relationship to the expected outcome
ANALYZING THE DATA	• Analyzes data using inappropriate methods or with major errors or omissions • Consistency of outcome with initial hypothesis is not compared		• Accurately analyzes data using appropriate methods with minor omissions • Compares consistency of outcome with initial hypothesis		• Accurately analyzes data in using appropriate and systematic methods to identify patterns • Compares consistency of outcome with initial hypothesis and identifies possible sources of error		• Accurately analyzes data in using appropriate and systematic methods to identify and explain patterns • Compares and explains consistency of outcome with initial hypothesis, and explains possible sources of error and impact of errors
GENERATING INTREPRETA-TIONS	• Inferences drawn from data are absent • Makes no mention of variables needing further investigation		• Draws inferences from data without discussing strengths or weaknesses • Makes note of variables that need further investigation		• Explains the strengths OR weaknesses of the inferences drawn from data using grade appropriate techniques • Suggests relationships or interactions between variables worth further investigation		• Explains the strengths AND weaknesses of the inferences drawn from data using grade appropriate techniques • Suggests relationships or interactions between variables worth further investigation and poses new analysis

CONSTRUCTING EVIDENCE-BASED ARGUMENTS AND COMMUNICATING CONCLUSIONS

What is the evidence that the student can articulate evidence-based explanations and effectively communicate conclusions?

SCORING DOMAIN	EMERGING	E/D	DEVELOPING	D/P	PROFICIENT	P/A	ADVANCED
CONSTRUCTING EVIDENCE-BASED ARGUMENTS	• Argument is missing or unclear; supporting data or scientific theory are missing • Counterclaim (possible weaknesses in scientific arguments or in their own argument) is missing		• Constructs a scientific argument and mentions data OR acceptable scientific theory but does not explain how it supports the claim • Identifies a counterclaim (possible weaknesses in scientific arguments or in one's own argument) without mentioning evidence		• Constructs a scientific argument, explaining how data and acceptable scientific theory support the claim • Identifies a counterclaim (possible weaknesses in scientific arguments or in one's own argument) using evidence		• Constructs and evaluates a scientific argument explaining how data and acceptable scientific theory support the claim • Explains and evaluates a counterclaim (possible strengths and weaknesses in scientific arguments or in one's own argument) using evidence
COMMUNICAT-ING FINDINGS	• Attempts to use multiple representations to communicate conclusions with inaccuracies or major inconsistencies with the evidence • Implies conclusions with no discussion of limitations		• Uses multiple representations (words, tables, diagrams, graphs and/or mathematical expression) to communicate conclusions with minor inconsistentencies with the evidence • States conclusions and general discussion of limitations		• Uses multiple representations (words, tables, diagrams, graphs, and/or mathematical expressions) to communicate clear conclusions consistent with the evidence • Explains conclusions with specific discussion of limitations		• Uses multiple representations representations (words, tables, diagrams, graphs, and/or mathematical expressions) to communicate clear and specific conclusions consistent with the evidence • Explains conclusions and impact of limitations or unanswered questions
FOLLOWING CONVENTIONS	• Uses language and tone inappropriate to the purpose and audience • Attempts to follow the norms and conventions of scientific writing with major, consistent errors, for example in the use of scientific/technical terms, quantitative data, or visual representations		• Uses language and tone appropriate to the purpose and audience with minor lapses • Follows the norms and conventions of scientific writing with consistent minor errors, for example in the use of scientific or technical terms, quantitative data, or visual representations		• Uses language and tone appropriate to the purpose and audience • Follows the norms and conventions of scientific writing including accurate use of scientific/technical terms, quantitative data, and visual representations		• Uses language and tone appropriate to the purpose and audience • Consistently follows the norms and conventions of scientific writing, including accurate use of scientific/technical terms, quantitative data, and visual representations