MINES Academy
High School Innovation Challenge
Presented by Red Rocks Community College

Spring 2023 Guidelines

Table Of Contents

MINES Academy »
at Red Rocks Community College

Introduction

Engineering is the profession of acquiring and applying scientific knowledge to balance the social (people), economic (profit), and environmental (planet) impacts when designing and building structures, machines, devices, systems, materials, and processes. Balancing the economic, social, and environmental impacts of a design makes it sustainable. As human populations continue to increase in Colorado and around the world the need for sustainable development has never been greater. The United Nations defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [1]. Securing a prosperous future for humanity depends on the contributions that science, engineering, and education will make towards building sustainable pathways to meet the needs of future generations

The Mines Academy High School Innovation Challenge presented by Red Rocks Community College is a competition that recognizes, and rewards designs for sustainable change. We invite teams of 3-5 high school students, grades 9-12, to participate in a real-world STEM challenge that will propose sustainable innovations around this year's Call for Proposals (CFP). Each team will be required to engage in the human-centered design process to define, innovate, and evaluate a solution to a specific problem related to the CFP. Teams will write a technical report and build a prototype which can be used to evaluate the impacts and benefits of their solution. The top five design teams from each high school will present their design solutions at the Design EXPO on **Thursday May 11th, 2023, beginning at 5:00pm on the Colorado School of Mines campus**. Participating teams will be eligible to win prizes in several categories detailed in Table 1.

Table 1: Competition categories with a description of each category's evaluation metrics. Category prizes will include Tech Prizes for every category, Scholarship money for Red Rocks Community College, and Career Exploration Opportunities. These prizes will be solidified by early in 2023.

Category	**Description**
Best in Show	Highest cumulative points earned for all categories of the rubric. This team has the most credible evidence of their problem, effective and innovative solution, analysis of their solution, and effective prototype. The report is well written and their EXPO presentation is highly effective
Game Changer	The team with the most out-of-the-box solution that has potential to transform how society addresses the problem identified.
Most Effective Analysis	The team that had the most thorough background research on scientific concepts and effective evaluation of their solution through experimentation, data analysis and/or calculations.
Most Advanced Prototype	The team that has the most evidence of technical fabrication learning stretches (coding, electronics, 3D printing, wood shop, etc...) and applied engineering skills (calculations, CAD drawings, etc...). An emphasis will be placed on the amount of learning the students did over how technical the end product is. Students should focus on explaining their learning process in the Prototype section to earn points in this category.

Call for Proposals – Sustainable Designs for Wildfire Prevention, Response, and Recovery

Wildfires in Colorado are a threat to our ecosystems [1], infrastructure [2], watersheds [3], and health and safety. Although wildfires are a natural and healthy part of an ecosystem, the severity and frequency of wildfires in Colorado have increased. In the last 20 years, Colorado has experienced 20 of the top 20 largest wildfires in the state's history [4]. Furthermore, the risk of wildfires is increased by "temperature, soil moisture, and the presence of trees, shrubs, and other potential fuels"; all of which are greatly impacted by climate change [5]. Projections based on a global temperature increase of 1 degree Celsius would result in a 600% increase of wildfire burning in some types of forests and double the total burn area by the mid 21st century [5]. Thus, as global temperatures rise due to climate change, the risk of severe wildfire will increase.

Wildland fires pose long term impacts to ecosystems by impacting the biodiversity of watersheds [3] and causing severe erosion [6]. These long term effects on the ecosystem can also cause increased risk to the estimated 3 million residents in Colorado who live in a wildland urban interface (WUI) where communities reside within wildfire prone areas. The impact on biodiversity can make it challenging to provide safe drinking water within those watersheds [3]. Severe erosion from hydrophobic soils leads to catastrophic flash flooding, causing damage to WUI communities and resulting in a major safety concerns for those individuals.

Wildfire prevention, response, and recovery for the detrimental impacts they have on ecosystems, infrastructure, and health is necessary for our society to adapt to climate change impacts. Therefore, the Mines Academy at Red Rocks Community College seeks novel, sustainable solutions to these problems.

The brunt of solutions should be technical in nature. Solutions should consider sustainability issues such as society or user needs, economic factors, and environmental impacts. Solutions designed by student teams should represent creative novel responses to some facet of the challenge. A novel solution is defined as a new or unique application of existing technology, a clear and distinct improvement upon existing technology (reducing cost, increasing environmental friendliness, improved user interface, etc...), or completely new technology.

Rules

- Each team is required to get input on their design from a Project Partner. A Project Partner could include mentors from business, engineering, a university professor, or a community organization. The purpose of a Project Partner is to improve student understanding of technical, social, cultural, and economic considerations specific to their problem and target demographic. Project Partners cannot be student's direct family members.

- The maximum prototype budget is $200. EXCEL energy and RRCC have several $200 grants available to qualifying classrooms to help offset these costs. See the Excel Grant Award section for more details. Prototype material lists and receipts will be collected as part of the design challenge submission. Materials that have been donated should be counted as part of the prototype budget. Materials that have been recycled or repurposed into your prototype will not be included in the prototype budget. Recycled and repurposed materials are defined as materials previously used for purposes not related to the project. Students are highly encouraged to repurpose or recycle materials to make their prototypes have less environmental impact.
- Technical reports are due no later than midnight April 28th, 2023.

Deliverables

Technical Report

The written report is a comprehensive description of your engagement with the human-centered engineering design process. Technical writing guidelines should be used throughout the report. Section headings should match the structure outlined below.

Problem Statement

Describe the specific problem you are working to solve including social, environmental and economic factors of the problem. Provide statistics, stakeholder feedback, background research, and supportive figures on the topic to convince the reader that your problem is real and significant.

- Statistics: population-based numbers that quantify how large of a problem this is.
- Stakeholder feedback: evidence of engagement in the human-centered design process to gain empathy for people who are directly impacted by the problem and/or may directly benefit from your solution.
- Background research: scientific information from credible sources that you gathered to understand the problem more deeply.
- Student generated figure(s) to support your writing for this portion is encouraged. Examples include:
    - Process diagrams of environmental systems which emphasize how the problem you are addressing occurs.
    - Student-generated graphs that visualize the impact of one variable on another which emphasize the severity of a problem.
    - GIS map data which visualizes geographic related problems.

Solution Description

This section should provide the reader with a clear understanding of your solution concept. This section must include:

- Written overview of how the solution works and solve the problem.
- Written overview of how the solution functions. The depth of this section depends on how technical the solution is.
- Figure(s) which help the reader understand the solution. For example:

- CAD images (encouraged for an Engineering Classroom)
- Computer drawing of concept (ie google drawings)
- Process or flow diagrams for process related solutions
- System diagram for more complex solutions

Include analyses that demonstrate the usability and feasibility of the solution. Analyses could include one or more of the following:

- Feedback from stakeholders and project partners.
- Calculations on the performance of any portion of your solution.
- Experimentation and evidence/data which informs trade off considerations and design decisions.

Sustainability Considerations

This section must highlight how student teams ensured they addressed the three pillars of sustainability: environment, society, and economy. Students should discuss prioritized criteria and tradeoff considerations for a range of constraints including cost, safety, reliability and aesthetics and to consider social, cultural and environmental impacts. Design decisions based on these prioritized criteria and tradeoff considerations should be supported by evidence in the form of student-generated research and/or project partner engagement. Students can use the following list of questions to help guide their decision-making process.

- Economic Impacts *will* include:
  - Cost analysis of full-scale solutions including material costs, manufacturing costs, and shipping costs. Cost estimates should be supported with citations.
  - How does this cost analysis compare to the local economy's price point? Who will pay for it? How do you know they can afford it?
  - Are there any hidden costs that should be considered such operation and maintenance costs of using the solution?
- Environmental Impacts *may* include:
  - What are the pollutants from manufacturing or operation of your solution?
  - What are the energy sources for manufacturing or operation of your solution? Can you ensure it is a renewable energy source?
  - Is there an end of product use life cycle? Can the materials be reused, recycled, or repurposed?
- Social and Cultural Impacts *may* include:
  - How will the community that is impacted by the problem benefit from your solution?
  - Are there any unintended consequences of the solution to the community or associated communities?
  - Is your solution equitable for all individuals and/or communities impacted by your problem?

Prototype

Describe your prototype, how you built it, where you built it and what you have learned from your prototype. Learning from your prototype can be technical skills AND improvements upon your solution. In other words, how would you improve upon your idea after your first prototype?

Describe any technical learning stretches your team engaged with to build your prototype. For example, did your team learn how to build circuits, write programs, or use a 3D printer? If so, what resources did you use to learn this new skill (tutorials, teacher-led, external mentor, RRCC lead workshops etc...)? Describe the set-backs or challenges you encountered and what you did to fix those setbacks.

Include figures to visualize your prototype. Figures could be annotated pictures of your prototype. Annotations should point out key portions of your prototype and describe their function.

Provide a budget for your prototype – identify all materials and indicate whether they were purchased, donated, repurposed or recycled. For purchased and donated materials, you must provide a link and/or receipt to demonstrate the cost of those materials. Provide a total cost including the cost of all donated materials. The budget should be presented in table format. You may use Table 2 and Table 3 templates to organize that information.

Table 2: Template for displaying all required information for all materials that have been purchased or donated as a new material.

Purchased and Donated Materials				
Material Description	**Cost of Material**	**Quantity Used in Prototype**	**Total Cost of Material for Prototype**	**Vendor and Link**
Example: ¼-20 Bolts	$1.38 per bag of 10	4	= $1.38 x (4/10) = $0.55	Home Depot
Total				

Table 3: Template for displaying all required information for materials that were repurposed or recycled. Repurposed and recycled materials are defined as materials previously used for purposes not related to the project.

Recycle and Repurposed Materials		
Material Description	**Source of Material**	**Purpose of Material**
Example: PVC pipe	Old catapult in school's makerspace	Piping for water

Design EXPO

All teams will participate in the **Design EXPO on May 11th from 5-7 pm** on the Colorado School of Mines campus at McNeill Hall. A design EXPO is a public display of student solutions in a common space where visitors and judges can interact with student teams in a face-to-face format. Students will be asked to give a 5-minute presentation using any visual aid(s) of their choosing. Visual aids could include posters, presentation slides, handouts, demonstration of prototypes, video clips, etc... After their presentation, judges will ask a series of questions for another 3-4 minutes. See the judges rubric for clarity on how students will be judged.