ABOUT

Avery County High School STEM Academy students complete a research-based STEM capstone project during their 10-12 grade years, that culminates in a final product. This document outlines the capstone project, with rubrics and guidelines that can be used by other schools to replicate Avery County High School’s capstone program.

CAPSTONE MISSION AND OVERVIEW

The STEM Capstone Project is designed to prepare STEM students for lifelong learning and effective and productive citizenship through the opportunity to plan, complete and present a self-directed culminating project reflecting their personal interest. Capstone projects are designed to encourage students to think critically, solve challenging problems, and develop skills such as oral communication, public speaking, research skills, media literacy, teamwork, planning, self-sufficiency, and goal setting; skills that will help prepare them for college, modern careers, and adult life. The projects are also interdisciplinary, in the sense that they require students to apply skills or investigate issues across many different subject areas and demonstrate the most important components of their K-12 learning. The STEM Capstone project guidelines also encourage students to connect their projects to community issues or problems, and to integrate outside-of-school learning experiences, including activities such as interviews, scientific observations, and/or internships.

STANDARDS AND SKILLS

The STEM Capstone Project is a progressive project, requiring students to demonstrate core values and standards and to apply key knowledge and skills. Essential standards and skills include:

1. Thinking critically and creatively
2. Demonstrating flexibility and initiative
3. Conducting analysis and research, including proper citation of references (print and web resources, interviews, etc.)
4. Communicating ideas through multiple modalities
5. Using technology effectively
PROCESS

The STEM Capstone Project reflects the belief that the processes inherent in learning are at least as important as the products. All STEM students should complete certain common processes each year. **Essential** processes include:

1. Developing and implementing a plan of action
2. Conducting research
3. Working with an advisor/mentor
4. Presenting/exhibiting through multiple modalities, with question and answer or other forms of interaction
5. Reflecting and self-evaluating

The STEM Capstone Project encourages students to utilize the Engineering Design Process. Each year, the project will progress through the process culminating with a final presentation during the senior year.
Sophomore Year: Ask, Imagine, Plan, Experiment

- Develop a comprehensive project proposal-see template and rubric in Appendix A and B.
- Research the problem/challenge and conduct activities or experiments that help develop solutions-this data will be included in your Junior Research Paper (see Appendix C-Evidence)
- Due in May

Junior Year: Plan, Experiment, Create

- Continue to conduct activities and experiments. Use data you gathered and write a research paper on the process and proposed solutions -see rubric in Appendix C.
- Due in May

Senior Year: Create, Improve

- Students will create prototypes of proposed solutions or develop a timeline of specific steps to develop/test the solution(s) and present their full body of work to a community panel- see rubric in Appendix D.
- Due the Semester you have Science or April if you are not enrolled in a science course

General Information-Steps that should be completed during your Sophomore and Junior Years:

1. Develop your own original idea for a scientific investigation (you must experimentally solve or investigate a problem using real data)
2. Conduct research that helps you develop a hypothesis
3. Plan experimental procedures using appropriate scientific methods or the engineering design process
4. Gather necessary materials and complete any necessary forms in a timely manner.
5. Perform the experiment, taking photographs and collecting data
6. Organize and display your data
7. Analyze your data and draw conclusions
8. Compile a formal report summarizing your work.
**Products to be shared during Senior Year presentation:**

The STEM Capstone Project provides students with several opportunities to showcase their work.

- Reflective journal/process log with diagrams and sketches included
- Final product/Prototype/Detailed Timeline visually explained including reflection and self-evaluation
- Presentation/exhibition **

**Be sure to include the following information in your presentation (at the very least):**

1. How did I choose my project?
2. What is the problem/challenge you addressed?
3. What did I do for my research paper/fieldwork/experiments? What insights did I gain from doing them?
4. What kind of problems did you encounter? How did you solve them?
5. How did this project impact your life or future plans/goals?

**You may use a PowerPoint, Keynote, Prezi, or other presentation tool but you must also include an exhibition of your findings in some other way as well.**
Sophomore Project Proposal Template

Your proposal is the first component of the STEM Capstone Project. The following items MUST be included in your proposal. Format will be double spaced, 1-inch margins on all sides, 12 pt. Times New Roman

Title Page
- Personal data (name, school name)
- Title of your research/capstone project—should identify the problem/challenge area (15 word maximum)

Abstract/summary statement of the research project:
- This one page summary focuses on the research topic and describes the problem/challenge you will address

Review of research literature
- A short and precise overview about the current state of research immediately connected with your research project
- Include at least 3 sources—at least sources 2 must be primary (other than an electronic/internet/web source)

Objective of the STEM Capstone Project
- Give a concise and clear outline or bulleted list of the goals/objectives you want to achieve through the process of your project.

Outline of the project
- Detail your planned research procedure(s)
- Describe the intended methods of data gathering and the controls you will introduce
- This will be a work-in-progress so allow for flexibility in your planning

Timetable
- Develop a timetable (in table format), including the sequence of research phases and estimated time you will need for each phase. Take into account that at this stage, this is only estimation, but make it clear that you have an idea about the time span necessary for each step and phase.

Selective research bibliography
- List academic works mentioned in your research outline as well as other important works that you will refer to during your research

Present your proposal in a Keynote presentation including the following five slides:
1. Title
2. Abstract-bulleted points only no more that 5 words per idea
3. Review of Literature-bulleted list that includes only the titles of the articles/sources you will use
4. Objective of the Project-bulleted phrases that describe your goals and purpose
5. Timetable-include dates only—days, weeks, months, and or years
6. Bibliography
# Sophomore Project Proposal Rubric

<table>
<thead>
<tr>
<th>STEM Project Proposal</th>
<th>Exemplary</th>
<th>Proficient</th>
<th>Developing/Emerging</th>
<th>Not Yet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Title Slide</strong></td>
<td>Includes descriptive title, author(s) name(s)</td>
<td>Title is not descriptive, author(s) name(s)</td>
<td>Does not include both a title or author(s) name(s)</td>
<td>Does not include either a title or author(s) name(s)</td>
</tr>
<tr>
<td><strong>Abstract</strong></td>
<td>Grammatically sound and clear formatting, includes topic, problem, background, procedures, and impact</td>
<td>Grammatically sound and clear formatting, includes topic, problem, background, procedures, and impact</td>
<td>Includes topic, problem, background, procedures, and impact</td>
<td>Is missing one or more components of the abstract</td>
</tr>
<tr>
<td><strong>Review of Research Literature</strong></td>
<td>Grammatically sound and clear formatting, includes current state of research, at least 3 sources of which two are primary sources</td>
<td>Grammatically sound and clear formatting, includes current state of research, at least 3 sources including one primary source</td>
<td>Includes precise overview and includes 3 sources</td>
<td>Overview does not cover research immediately connected with your project or contains fewer than 3 sources</td>
</tr>
<tr>
<td><strong>Objectives of STEM Capstone Project</strong></td>
<td>Grammatically sound and clear formatting, includes concise and clear outline or list of goals and objectives of your project</td>
<td>Grammatically sound and clear formatting, includes a list of some goals and objectives of your project</td>
<td>Includes an incomplete list of goals and objectives of your project</td>
<td>Does not identify goals or objectives</td>
</tr>
<tr>
<td><strong>Project Outline</strong></td>
<td>Grammatically sound and clear formatting, includes details of your planned research procedures, methods of data collection and controls for your project</td>
<td>Grammatically sound and clear formatting, includes some information about your planned research procedures, methods of data collection and controls for your project</td>
<td>Includes some information about your planned research procedures but data collection methods and controls are incomplete</td>
<td>Research procedures and methods are unclear</td>
</tr>
<tr>
<td><strong>Timetable</strong></td>
<td>Grammatically sound table format that includes sequence of research phases and time for each phase that demonstrates understanding of necessary time span</td>
<td>Uses table format that includes sequence of research phases and time for each phase</td>
<td>Includes sequence of research phases and time for each phase</td>
<td>Does not include estimated time for each phase</td>
</tr>
<tr>
<td><strong>Bibliography</strong></td>
<td>APA format used consistently and correctly throughout the paper</td>
<td>APA format is used within the paper</td>
<td>APA format attempted with multiple errors</td>
<td>Does not use APA format</td>
</tr>
<tr>
<td><strong>Presentation Tool Quality</strong></td>
<td>Grammatically sound slides that include all required information in an interesting format and do not include too many words</td>
<td>Grammatically sound slides that include all required information in an interesting format but include too many words</td>
<td>Slides are not interesting or contain too many words</td>
<td>Slides do not include all required information</td>
</tr>
</tbody>
</table>

Comments:
Appendix C

Junior Project Proposal Rubric

Checklist

☐ Title
☐ Author(s) Name(s)
☐ Abstract - summary paragraph
☐ Introduction
☐ Thesis Statement or Hypothesis
☐ Background Paragraph
☐ Evidence
☐ Supporting Information
☐ Materials used in experiment(s)
☐ Methods
☐ Data (tables/graphs)
☐ Conclusion
☐ In-text Citations
☐ Works Cited Page
☐ Paper should be grammatically sound with clear formatting (easy to read and follow)
# Appendix C

## Junior Project Proposal Rubric

<table>
<thead>
<tr>
<th>Research Paper</th>
<th>Exemplary</th>
<th>Proficient</th>
<th>Developing/ Emerging</th>
<th>Not Yet</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Title Page</td>
<td>Includes descriptive title, author(s) name(s)</td>
<td>Title is not descriptive, author(s) name(s)</td>
<td>Does not include both a title or author(s) name(s)</td>
<td>Does not include either a title or author(s) name(s)</td>
<td></td>
</tr>
<tr>
<td>Abstract/Summary paragraph</td>
<td>Grammatically sound and clear formatting, completely and concisely includes topic, problem, background, procedures, and impact</td>
<td>Grammatically sound and clear formatting, includes topic, problem, background, procedures, and impact but does not use scientific terminology</td>
<td>Includes topic, problem, background, procedures, and impact</td>
<td>As missing one or more components of the abstract</td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>Grammatically sound and clear formatting, summarizes current understanding of problem, and identifies hypothesis, question or problem investigated</td>
<td>Grammatically sound and clear formatting, either summarizes current understanding of problem, or identifies hypothesis, question or problem investigated</td>
<td>Includes hypothesis or current understanding of problem but is not clear or focused</td>
<td>Does not adequately define the project</td>
<td></td>
</tr>
<tr>
<td>Background Paragraph</td>
<td>Grammatically sound and clear formatting, consolidates current research from 3 or more primary sources</td>
<td>Grammatically sound and clear formatting, consolidates current research from 2 primary sources</td>
<td>Consolidates current research from less than 2 primary sources</td>
<td>Does not include primary sources</td>
<td></td>
</tr>
<tr>
<td>Evidence/Supporting Information</td>
<td>Grammatically sound and clear formatting, All information from experiment(s) included: methods, methods, data tables and charts, data analysis for multiple trials or secondary research</td>
<td>Grammatically sound and clear formatting, Most information from experiment(s) included: methods, methods, data tables and charts, data analysis for limited trials or secondary research</td>
<td>Some information from experiment(s) or secondary research is included: missing more than one component</td>
<td>Does not include information from experiment(s) or secondary research</td>
<td></td>
</tr>
<tr>
<td>Conclusion</td>
<td>Grammatically sound and proper formatting, identifies if and how the hypothesis was supported. Future research and experiments are considered</td>
<td>Grammatically sound and proper formatting, identifies if and how the hypothesis was supported</td>
<td>Identifies if the hypothesis was supported but does not include new</td>
<td>Does not include support for or against the hypothesis</td>
<td></td>
</tr>
<tr>
<td>In-text citations</td>
<td>APA format used consistently and correctly throughout the paper</td>
<td>APA format is used within the paper</td>
<td>APA format attempted with multiple errors</td>
<td>Does not use APA format</td>
<td></td>
</tr>
<tr>
<td>References Page</td>
<td>APA format used correctly for at least 3 primary sources</td>
<td>APA format used on less than 3 primary sources but includes secondary sources</td>
<td>Lacking proper format or required number of sources</td>
<td>Lacks both proper format and too few sources</td>
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## Senior Project Proposal Rubric

<table>
<thead>
<tr>
<th>Communication Skills</th>
<th>Exemplary</th>
<th>Proficient</th>
<th>Developing/Emerging</th>
<th>Not Yet</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(No Revision Needed)</td>
<td>(Some Revision Needed)</td>
<td>(Revision Needed)</td>
<td>(Remediation and Revision Needed)</td>
</tr>
<tr>
<td>All group members consistently speak with appropriate volume, tone and articulation</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Consistently employs good eye contact and posture</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Consistently employs appropriate nonverbal communication techniques</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Consistently exhibits poise, enthusiasm and confidence</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Wears appropriate professional or authentic attire related to the topic</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Adheres to prescribed time guidelines (7-10 minutes)</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Employs creative use of visual aids that enrich or reinforce the presentation**</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

**Note: A basic Keynote or PowerPoint presentation or poster will not earn a 4**

### Comments:

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**Exemplary**
- All group members consistently speak with appropriate volume, tone and articulation
- Consistently employs good eye contact and posture
- Consistently employs appropriate nonverbal communication techniques
- Consistently exhibits poise, enthusiasm and confidence
- Wears appropriate professional or authentic attire related to the topic

**Proficient**
- Generally speaks with appropriate volume, tone and articulation
- Adequately employs good eye contact and posture
- Adequately employs appropriate nonverbal communication techniques
- Generally exhibits poise, enthusiasm and confidence
- Wears appropriate school attire and is neat and put-together

**Developing/Emerging**
- One or more group members has difficulty speaking with appropriate volume, tone, and articulation
- Infrequently employs good eye contact and/or poor posture
- Employs limited nonverbal communication techniques
- Exhibits limited poise, enthusiasm and confidence
- Appears sloppy or is in jeans, t-shirt, etc.

**Not Yet**
- Does not speak with appropriate volume, tone and articulation
- Does not make eye contact
- Does not employ appropriate nonverbal communication techniques
- Lacks poise, enthusiasm and confidence
- Does not comply with school dress-code
- Significantly does not comply with time guidelines
- Uses no visual aids
<table>
<thead>
<tr>
<th>Content &amp; Coherence</th>
<th>4</th>
<th>Adequately defines a challenge/problem and adheres to the main idea throughout the presentation</th>
<th>3</th>
<th>Insufficiently defines the main challenge/problem but adheres to the main idea throughout the presentation</th>
<th>2</th>
<th>Does not define a main challenge/problem</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employs a logical and engaging sequence which audience can follow</td>
<td>4</td>
<td>Employs a logical sequence which audience can follow</td>
<td>3</td>
<td>Employs ineffective sequence confusing the audience</td>
<td>2</td>
<td>Lacks and organized sequence</td>
<td>0</td>
</tr>
<tr>
<td>Includes all 5 required components and use of supporting details/evidence</td>
<td>4</td>
<td>Includes most of the required components along with supporting details/evidence</td>
<td>3</td>
<td>Includes some required components and some supporting details/evidence</td>
<td>2</td>
<td>Does not include supporting details/evidence</td>
<td>0</td>
</tr>
</tbody>
</table>

**Comments:**

<table>
<thead>
<tr>
<th>Reflection</th>
<th>4</th>
<th>Offers an insightful evaluation of the project process</th>
<th>3</th>
<th>Offers an evaluation of the project process</th>
<th>2</th>
<th>Fails to offer an evaluation of the project process</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reflects on successes and challenges with exceptional depth and insight</td>
<td>4</td>
<td>Reflects on successes and challenges with sufficient depth and insight</td>
<td>3</td>
<td>Reflects on successes and challenges with limited depth and insight</td>
<td>2</td>
<td>Does not reflect on successes and challenges</td>
<td>0</td>
</tr>
</tbody>
</table>

**Comments:**

<table>
<thead>
<tr>
<th>Response</th>
<th>4</th>
<th>Confidently, politely, and accurately responds to judges’ questions and comments</th>
<th>3</th>
<th>Ineffectively responds to judges’ questions and comments</th>
<th>2</th>
<th>Unacceptably or does not respond to judges’ questions and comments</th>
<th>0</th>
</tr>
</thead>
</table>

**Comments:**
High School Traffic Patterns
A team of students spent time evaluating the traffic patterns for the high school parking lot during peak times and then developed different routing plans and parking lot designs to minimize time spent in traffic in front of ACHS. The goal was to cut down on the time cars waited in line to pick up and drop off students in order to cut down on automobile exhaust pollution. These students presented their plans to representatives from the Department of Transportation.

Solar Energy at Avery High School
A team of students met with a representative from O2 Energies who wanted to place a solar panel array on ACHS property to provide electricity to send back to the electrical grid and allow Avery County Schools to receive a discount on their electricity. The group toured the high school property and identified a couple of possible sites. They the students presented information about how solar power worked, why these sites would be best, and why it is important to incorporate renewable energy sources to our Board of Education.

Solar Powered Electric Car
A pair of students spent time mechanically working and fixing the Google Gravity Car to its current state. Attaching a structural roof and frame, motor mount, steering, and axle structure. They also developing the wire circuitry to power the small battery based vehicle for a competition using nothing but renewable energy. This project still has opportunity and potential to go further and be placed into a real competition in the future.

Underground Hydroelectric Dams
This student worked independently and researched the designs, engineering and impact of underground hydroelectric dams and their possible contribution to clean renewable energy.

Vinyl Records vs. Digital Music Quality
This student primarily performed research on the sound quality and benefits of modern music storage verses vinyl. Really interesting topic and the student found a lot of interesting data to support her topic. Could easily be turned into an experiment.
Water Pollution and its Effects on an Aquatic Ecosystem

A group of students ran trials using laundry detergent, which can often lead to non-point source water pollution. They monitored the pH change and the effect on plants normally found on the banks of streams and creeks.

Feed Comparison for Backyard Egg Production

This student tested out two versions of feed on backyard chickens and measured egg production to determine a relationship between the two.

Sustainable Agriculture

A team of students researched different methods of farming vegetables and herbs, and built raised beds to plant in, used compost from their Vermiculture project (growing worms to make compost) and cut bamboo for stakes and fences. These students worked hard to find ways to plant more in less space and increase yield, while preserving and improving the environment. The area outside of the greenhouse complex was not conducive to gardening, but by using wood chips and compost, they created raised beds and are improving the existing soil as well. These students presented their project locally and went to Raleigh to present at the STEM Conference.

The Inclusion of Art in STEM=STEAM

When the STEM Academy was still in its early stages, I had a student who felt that they were STEM in terms of what the academic workload meant, but did not have an interest in pursuing a career in a STEM field. The process of coming up with a STEM project was extremely challenging, especially since one of the goals was for students to work collaboratively rather than individually. This student was doing a paper-making project for art class, which several teachers suggested become the STEM project. A fellow STEM student and friend asked to work on the project from the scientific side, covering the paper making process at the industrial level, bringing out past and current environmental impact. The process itself was highlighted from both an artistic and a conservation standpoint, as all the ingredients were things that would normally be thrown away. Some of the best final product pages were made from dryer lint or onion skins. I feel like this project truly embodied what STEM is about. STEM is not a field or a subject, but a thought process. STEM is a different lens to look through that shows challenges in a new light and highlights innovative solutions that are outside the box.
**Repurposing and Recycling “Garbage”**

One group built a “green house” out of recyclable plastic bottles and flower-beds out of recyclables. They constructed a small model for their presentation. They got the idea for this project from reading *The Boy who Harnessed the Wind*. That year, other students made toy cars from trash to give to first graders at a local elementary school, and another group made a bird house out of recyclable materials.

**Other Sustainable Gardening Topics**

Sustainable gardening to help people to grow their own food and to be able to control fertilizer, pesticides or other factors; Raised beds can produce enough food for a family of four and recycled materials can be used to build the beds; Recycled food waste (peels) can be used to enrich the soil as organic fertilizer and compost; School garden can be certified and used to supplement cafeteria or culinary programs; These examples incorporate math, and science, use STEM principles, and also include beautification and ecological improvement.

***NOTE: There have been several great projects over the years that are not included in this appendix. If you have an idea or would like a more specific description, please see one of the STEM Faculty members and they would be happy to discuss a topic with you.***

**Authors**

Kim Davis, CTE & STEM Director, Avery County Schools
Jennifer Hurst
Susan Hawkins
Neva Winters

This STEM Capstone Project guide was developed at Avery STEM Academy and is made available under a Creative Commons Attribution Noncommercial Share-alike license (CC BY-NC-SA 4.0). These guidelines and rubrics are based on experiences and research from Avery High STEM Academy and the Summer Ventures program, a no-cost, state-funded program for academically talented North Carolina students who aspire to careers in science, technology, engineering, and mathematics. [https://www.ncssm.edu/summerventures](https://www.ncssm.edu/summerventures)