Student Driven Research

(Time Frame: Throughout Research Course or Independent Lessons)

Authors

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SUBJECT/GRADE LEVEL

Subject: Science, Math, English, Research

Grade Level: High School

Materials

- Materials for labs student conduct. All chemicals can be found on Amazon. Used with the Practice Experimental Design Data Collection Lab.
  - 50 ml Blue Solution (.5M Cu_2Cl)
  - Aluminum Foil
  - Guk (sodium polyacrylate found on Amazon)
  - 1 ml- Universal indicator
  - 50 ml- 1M HCl
  - 15 ml - .5 M Sodium Carbonate solution
  - 200 ml Acetic Acid CH_3COOH.
  - Sodium bicarbonate, $NaHCO_3$,
  - Collection bin
  - Canister

- Materials for student research projects are based on what the students are researching. Unfortunately, this does limit students' projects. Many research tools can be made, purchased inexpensively, or use materials already used in class.
  - Grants or classroom funding sites are great ways to obtain resources for students to conduct research. Non-consumable resources will enable students to use the tools for many years to come.

STANDARDS

Next Generation Science Standards

- HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

- HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.
- HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Mathematics Standards | Common Core State Standards

- CCSS.MATH.CONTENT.HSS.ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots).
- CCSS.MATH.CONTENT.HSS.ID.A.2 Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
- CCSS.MATH.CONTENT.HSS.ID.A.3 Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
- CCSS.MATH.CONTENT.HSS.IC.B.3 Recognize the purposes of and differences among sample surveys, experiments, and observational studies; explain how randomization relates to each.

English Language Arts Standards | Common Core State

- CCSS.ELA-LITERACY.RST.9-10.1: Cite specific textual evidence to support analysis of science and technical texts, attending to the precise details of explanations or descriptions.
- CCSS.ELA-LITERACY.RST.9-10.3: Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks, attending to special cases or exceptions defined in the text.
- CCSS.ELA-LITERACY.RST.9-10.6: Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, defining the question the author seeks to address.
- CCSS.ELA-LITERACY.RST.9-10.7: Translate quantitative or technical information expressed in words in a text into visual form (e.g., a table or chart) and translate information expressed visually or mathematically (e.g., in an equation) into words.
- CCSS.ELA-LITERACY.SL.11-12.1.A: Come to discussions prepared, having read and researched material under study; explicitly draw on that preparation by referring to evidence from texts and other research on the topic or issue to stimulate a thoughtful, well-reasoned exchange of ideas.
- CCSS.ELA-LITERACY.RST.11-12.1: Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.
- CCSS.ELA-LITERACY.RST.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.

- CCSS.ELA-LITERACY.RST.11-12.8: Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.

LESSON OBJECTIVE(S)

Students will create a research claim and support the claim through supporting evidence to design and conduct a student designed research project.

CAREER CONNECTION(S)

Mentor Background: Dr. Suzanne McLendon is a failure analyst and materials engineer at the U.S. Army Redstone Test Center (RTC). She currently supports Category I Product Quality Deficiency Reporting (PQDR) failure analysis and materials testing for aviation components across multiple platforms. She also provides extensive materials testing and evaluation support to numerous other programs. She received her Bachelor's, Master's, and Doctorate degrees from The University of Alabama in Metallurgical Engineering and Materials Science. While earning her graduate degrees at The University of Alabama, Suzanne was a NASA Space Technology Research Fellow, and was also awarded the NASA Alabama Space Grant Consortium Fellowship. Suzanne's research collaboration with NASA Glenn Research Center focused on developing a new class of high temperature shape memory alloys, and resulted in multiple publications and conference presentations. Suzanne has a passion for mentoring, and has mentored multiple engineering undergraduate and graduate students, as well as junior engineers at RTC. Dr. McLendon worked with The University of Alabama Metallurgical Engineering Department senior design class for many years to educate students in the niche area of failure analysis. Suzanne also serves on The University of Alabama Metallurgical Engineering Department Advisory Board. Suzanne actively participates in STEM (Science, Technology, Engineering, and Mathematics) outreach for middle school and high school students, and in encouraging women to pursue the field of engineering.

STEM Careers: Researcher, STEM Careers, Engineer

ENGAGEMENT

Brief Description: I wonder. This activity allows students to explore things they are curious about and brainstorm ideas. This activity prompts students inquiry through research explorations. Students will first brainstorm ideas to conduct a research project that pertains to their interests.

Procedures:

Introduction – Begin with a discussion. Ask students what to reflect and identify potential issues or problems that they are interested in exploring.

Possible Ideas/Options to Consider:

- Video from STEM Careers Coalition - Options: Senior Scientist, Product Researcher, Senior Researcher, Data Scientist, AI Researcher

- Video from Crash Course: Papers & Essays, Sociology Research Methods, Sociology & the Scientific Method, Ethical Data Collection
- Videos from MythBusters, Mark Rober, CSI to get students thinking about how people solve problems.
- Videos from RESET research partners.

Research I Wonder – This activity gets students to brainstorm and generate ideas for potential research project topics. Teacher notes are included on the document.

EXPLORATION

Brief Description: The following activities can be used as stand-alone lessons or supplemental activities to help students select a research project that will be engaging and relevant.

Procedures:

Scientific Methods and Graphing Notebook – This notebook gives students the tools needed to be successful while doing their research project. Students are asked to identify types of variables, create data tables and graph data. There are some CER scenarios that can be used as a review. This notebook can be assigned as a bellringer, class activity, or homework assignment.

Research Topic Selection – This presentation is done in class as a lecture/class activity to help students pick a topic for their research project. Students can use ideas from their I wonder document to help them select topics that interest them. They can then take those ideas into their Getting Ready to Research and focus down to one or two ideas.

Getting Ready for Research – This activity helps students take their topic ideas and narrow down to the best one for them.

- Identify a problem – These presentations are designed to help students who are struggling to select a topic. They can be used independently or as a small group.
- Idea generation diamond – This presentation helps students narrow down and figure out topic ideas.

EXPLANATION

Brief Description: This is the main section of the student designed research unit. Any of the pieces below can be used as stand-alone lessons or supplemental activities as part of the whole unit.

Procedures:

Article Analysis – These article analysis graphic organizers guide students as they read reputable sources to help them narrow down their ideas and start building their project. On each document is a discussion of what is a reputable source. Analysis one has question stems for students to complete that can guide their article analysis (background research). Article analysis three has a checklist to help students determine their progress and their future steps. Students usually do three or more article analyses before moving on. This is a crucial step because it will guide students in how to move forward.

- Article Analysis 1 – Done as a guided activity to ensure students understand expectations. Students write notes as we work together so they can refer back to this document when doing independent work.
- Article Analysis 2
- Article Analysis 3
- Article Analysis 4
- Article Analysis 5
- Extra Article Analysis
- Research Websites This is links to websites to help students find reputable sources for articles, places to gather data.

Research Summary – With this activity, students summarize their ideas they have already, put their thoughts down. This will help them focus and better prepare them for the next stage of their project, problem statement, research question, and hypothesis. The more time they put into these beginning stages, the easier each piece that follows will be. This activity can be optional based on the student's ability. This activity would be used with students who are struggling and cannot move on to their problem statement, research question, and hypothesis easily. In other words, the students who just don't know what they want to do.

Problem Statement, Research Question, and Hypothesis - This document helps students design and write their problem statement, research question, and hypothesis. Each of these pieces will help them design a hypothesis that will be testable and based on the work that they have been doing up to this point.

- This document also serves to help students organize all the work you have done so far.

Fundamentals of Experimental Design – This pogil will help students determine the key ideas for designing an experiment and data that needs to be collected. Students struggle with experimental design and lead to an easier time when completing their experimental design.

Practice Experimental Design Data Collection Lab – These three short labs have students practice the essential skills necessary to know what data to collect, how to organize a data table, and how to construct a procedure that is reproducible.

ELABORATION

Brief Description: These pieces take what students have completed so far and elaborates their work which results in students being able to design data tables and an experiment.

Procedures:

Data Table – Students in this part design their data table. Designing the data table before writing their procedure helps students focus on their procedure and what data they will need to collect. If students are doing surveys, this is where they build their survey rather than designing their data table. If they use

google forms, the form will allow them to extract the data from the data table that is built from their forms as a tool of google forms.

Design the Test – These ppt slides modified from Google Science Fair handouts familiarizes students with ways to test, methods of testing, and refining their procedure.

- Cubing Activity – Used with Design the Test slides to help students build their procedure.

Designing an Experiment – This step guides students through designing their experiment. Based on the type of experiment, they select one of the linked templates. Many students struggle with writing out each step of the procedure as a list or knowing what data to collect. By creating the data table first, it should help with knowing what data to collect and hopefully how to collect their data.
After students have completed designing the experiment, they begin doing their research. Collecting data, making observations, engineering a product. I allow three months for this with frequent check-ins. If you look at the data table template, you can see that I have left two columns for verification of progress by teachers and teacher comments.

Data Analysis and Statistics – In this presentation, students will learn about data analysis by learning how to calculate the correlation coefficient, calculate measures of central tendencies, and learn about data collection, and sampling techniques.

Data Visualizations (Graphing) - In this presentation, students will learn how to select appropriate graphs to model the data.

Potential programs to analysis and/or model data:

- Spreadsheets: Google Sheets, Excel, etc.
- CODAP (good for simple visualizations)
- More Advanced Options (coding may be required): CoLab, RStudio, Google Data Studio

Helpful Resources for Data Visualizations:

- Data Visualization 101: How to Choose a Chart Type
- How to choose the best chart or graph for your data
- Communicate the Results – This pptx can guide students to how they should display the data they gather.
- If your students have Google Accounts, teachers may want to consider using Learn-by-Doing Activities (pdf) that utilize various Google Tools.

EVALUATION

Brief Description: At this point in the lesson, students show what they have learned. They are now able to put together what they learned through their background research, their personal research, and data analysis to demonstrate their knowledge of the scientific process.

Procedures:

Conclusion Guide – This guide provides steps for students to write a research conclusion.

Writing an Abstract – This guide helps students write an abstract for their research project.

Research Poster Template – This template gives students options on how to display their work. After research projects are done, students participate in a gallery walk reviewing other students' work. Additionally, student projects that score 80% or better are included on a webpage to publicly display student research projects.

REFERENCES

- Google Science Fair
- ISEF
- Society for Science and the Public
- Science Buddies

Other Resources:

These are resources that can be used to help with tracking projects, progress, providing valid audiences outside the classroom (competitions), and readings to help students.

Teacher Resources – These are resources that will simplify the process especially if you have students competing in student research projects.

- Competition Links
  - Agriscience Fair
  - Biotechnology Institute
  - eCybermission
  - ISEF - Need to look for a regional / state fair, compete there and then qualify for this fair
  - National American Indian Science & Engineering Fair
  - Junior Science and Humanities Symposium
  - Institute of Competition Sciences
- Student Roster and Paperwork Tracker

Student Resources – These are resources that will help students be successful in doing their research project

- Project Schedule – This can help students keep track of what they have done, key deadlines, and what they still need to do. Needs to be updated to reflect the due dates for the teacher's class prior to giving to students.
- Research Project Time Log – This time log helps students document their work as they do it. This is a good tool for students going to competitions.
- STEM Student Research Handbook – If doing a full time research class or have a student doing an advanced project, this book is an excellent resource. It can be found online at NSTA or Amazon
- Student Research Handbook – Southern Utah University