

STARRS Field Science: Student Driven Research

When

Prior to, during, and after the expedition

Discipline

Applicable to all sciences descriptions

Description

In groups of 4-5, students develop answerable questions about MHS, and design their investigations and data collection procedures. Next, they carry out their investigations in the field during the expedition, perform simple data analysis, and present their findings and challenges to authentic audiences both at E:Y! and back in their own communities.

Learner outcomes

The student will:

- Apply previously gained knowledge in a self-designed research project
- Participate as scientists in the cycle of scientific inquiry

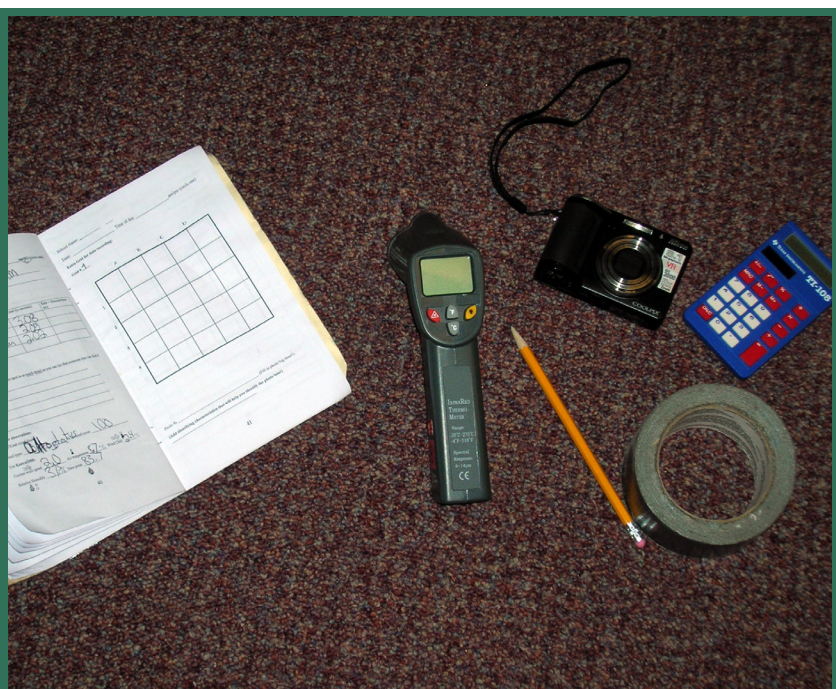
Materials

- Students will need access to all tools necessary for developing questions, developing procedures for data collection, data collection, analysis, and presentation.
- The latter portion may include large paper and markers for developing posters for presentations, or computers and a projection system.
- Background information that is found within this curriculum will be helpful.
- The complete grid protocol contains vital information on data collection in the field. If students have not been exposed to this, it would be good to have copies on hand while they are trying to figure out which tools they need to answer their questions.

Various field tools may include: pH strips, IR thermometers, probe thermometers, microbial charts, Kestrels[®], compasses, meter sticks, transect grids, digital cameras, etc. (The actual materials needed for the research studies will be dependent upon the final questions created by the students).

Background

Student-driven research provides a capstone-type activity for the students. Students will need guidance in how to do appropriate research. If you have done the previous lessons in the unit, then connect these skills to the investigation with your students. If you have not, it would be helpful for you (the teacher) to review the other lessons in this section. This knowledge will help you to guide your students to use tools, ask the answerable questions, and understand scientific components (biological, geological, chemical) of Mammoth Hot Springs as they develop their research while for E:Y!



Student Experience LESSON: Student Driven Research

EXPEDITION: YELLOWSTONE! STARRS

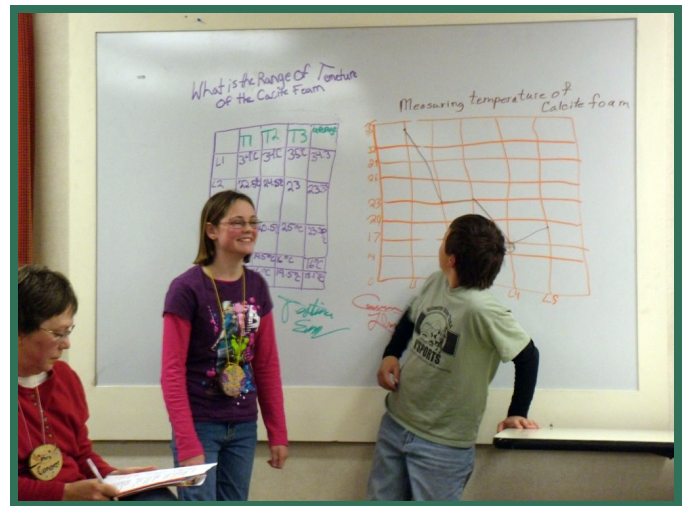
There are three stages of the student-driven research project: pre-expedition, during-expedition, and post-expedition. Each of these is critical to the full experience. The student-driven research at YNP cannot occur if the pre-expedition lessons are not completed.

Because this is a culminating activity, it will be most successful if the following lessons (or similar lessons or activities) are completed before the expedition:

- Use of all tools
- Developing answerable questions
- Facies model background and lessons
- Powers of ten lessons
- Grid/transect protocol lessons

Suggested procedure

Before the expedition the teacher will:



1. Encourage students to brainstorm a list of current scientific research topics. Using discussion as a vehicle to determine what research topics have they seen in the news, heard about in conversations, seen in commercials, or discussed in class.

As students participate in research partnerships with scientists – or prepare to do formal research, it is critical that they recognize why the research they are completing is important. Doing experiments simply to do experiments does not assist students in building understanding of the concepts researched or help develop a love of science. However, with some discussion on how their research is linked to global questions, even the smallest research question becomes important.

There are several “big idea” questions that span many disciplines in science. These big idea questions are currently the hot topics for many research scientists.

While each scientist has one or two of these big ideas in mind when doing research, they are often working on questions that are significantly smaller.

These big idea questions are

- What were the ecological conditions at the time of the origin of life?
- What are the changes that occur due to interactions between the living (biotic) and nonliving (abiotic) components in the environment?

For example:

- How is life controlled by the precipitation of minerals?
- How is the precipitation of minerals controlled by life?
- How will ecosystems respond to global climate change?

When assisting students in creating answerable questions for STARRS research, it can be beneficial to start with these questions. Discussions with students can point to current research in various scientific fields. As students evaluate current research (provided by the teacher), ask them to determine “why” the scientist is doing the research.

Think of the question, “So what?” As in, “So what? Why do we care about this research?” Students should be able to relate the individual, smaller research projects to the topics of global climate change, origins of life, and ecological interactions. It is also helpful to have the students deduce these broad research areas; these topics are likely ones the students are interested in.

Once the students have determined the “big idea” questions, conversation can turn to what the students would like to learn more about. STARRS field research questions can be developed around any of the big idea questions. STARRS research questions must be answerable; however, the development of these questions will often start with questions that are not answerable in a single (or even multiple) research project. The process of narrowing the question may take a long time. This process is critical, as it helps the students recognize the need for answerable questions and how these questions relate to the important scientific discussions of the day. As these discussions continue, use the Powers of Ten vocabulary (see P10 background and lessons) and answerable questions information (see resources at the end of the Asking Answerable Questions lesson) to help students determine appropriate research questions. But always have them ask “So What?” How does this research topic help us understand the big idea question a little bit more? Or, how does this research topic lead us to other questions that might help answer that question?

- 2.** As a list is created, the teacher will work with the students to categorize the research topics into groups of big-picture questions scientists are currently trying to answer (see background notes on question development in Green box):
 - a.** Origins of Life
 - b.** Interactions between abiotic and biotic factors
 - c.** Global Climate Change
- 3.** Divide the students into groups based on interest in one of the four areas. It is not necessary to have all four areas studied; multiple groups can study the same big-picture question.
- 4.** Assist the groups in determining two or three plausible questions to study while at YNP*. It is important the questions be answerable at YNP (and specifically at Mammoth Hot Springs and not just in any laboratory), be adjustable, use the available tools, and fit within one of the big-picture questions.

out to students, but instead they should be used as a guide by the teacher to help students develop and/or refine their own questions.

Once each group determines their possible questions, they need to develop their hypothesis and procedure as well as do some background research. A good place to start would be the to Google YNP, Hot Springs, and Research. The YNP and SERC sites will be most accurate and helpful. Working with the students on flexibility is key; it is highly likely that a question created will have to be adjusted once at YNP, due to weather, changes in hot springs, and access in the park. (At least 50% of the student groups who participated in student investigations during the 2008-09 school year needed to change their questions in the field. When groups had a second question ready to go, or had spent a lot of time thinking about the development of their original question, their ability to shift easily in the field was greatly enhanced.)

*There is a list of examples of questions at the end of these procedures. These questions have been investigated at MHS in the past. It is not the intent that this be passed

Prior to leaving for YNP, the teacher will:

- Make sure students have these questions and procedures for answering them, (along with the possible alternate ideas) ready for E:Y!
- Have chaperones participate in this process, as it will give them a better understanding of the field science process at YNP. However, chaperones must also be instructed that this is student-driven research and their role is a supporting one.

During the expedition the teacher will:

- Gather information from the rangers regarding availability of tools, hot springs, time, etc.

Responsibilities in the Field:

It is critical for the teacher to understand that the rangers will facilitate access to the hot springs areas, monitor safety procedures, and help answer general questions. However, the teachers and chaperones are responsible for the research groups and guiding the children through the research process in the field.

- 1.** Work with groups to determine if their questions are still answerable. If not, help students rework questions or design new ones. At times, questions can still be answered, but procedural steps may need to be altered.
- 2.** Assist students in creating appropriate data collection sheets. They may need tables, charts, pictures, sketches, etc. Remind students that all variable data (temperature, pH, flow rate, etc.) needs to be taken three times. (See the Protocol Lesson for an explanation for why this is important) Also remind students that it is better to collect more data than less; they will not be able to return to the site. Remind them to take lots and lots of photos! Once questions, procedures, and recording plans have been adjusted, head into the field.

One of, if not the most important section of the scientific inquiry model is communication of findings. If students do not share their findings with others, then in essence, they have not processed the research or determined the value of their findings. Communication of findings needs to occur both immediately after research and later, when more formal processing has occurred. Communication immediately following the research allows students to quickly analyze the data collected while the research is still fresh in their minds. Then, later, when they have had more time to analyze the data fully and discuss their findings in small groups, the students can come to more in depth conclusions. In STARRS, we refer to these two times as “in the field” and “at home.” In the field presentations will not be as polished as at home presentations; however, some of the most thoughtful and meaningful discussions can come from the in the field sharing, as the experience is fresh; these should not be skipped!

In the field, the teachers, chaperones, and rangers will:

- 1.** Work with all groups, ensuring that safety precautions are being followed and appropriate and thorough data are being collected.



In the field at E:Y!, the teacher will:

- 1.** Facilitate discussions about the field work. Where this is accomplished is dependent on time, location, and weather. The best option is for student groups to have 20-30 minutes to create displays in order to present on the five areas mentioned below. However, even if there is limited time and materials, presentations should still occur, and should briefly cover all five aspects. In this way, students can quickly provide classmates with a quick understanding of the question asked and the findings discovered.

Presentations need to be done at E:Y!

This immediate processing of the information is critical for the students to do while the research is fresh in their minds. This is the point where it all comes together and chaperones and students “get it!” Without the opportunity to do this right away, the moment can be lost – including all of the learning that has taken place prior to and during E:Y! Presentations should be also be audio-recorded and all materials from the presentations and research should go back to the school.

- 2.** The presentation should contain:
 - a.** Question and Hypothesis - State your research question and hypothesis if there was one – descriptive questions will not have hypotheses. You may have made predictions instead of or in addition to your hypothesis – state these as well.)
 - b.** Procedure - Briefly describe the procedures used. You may also want to display or explain some of the equipment you used.
 - c.** Results (in chart or graph form) & Conclusions- Explain your preliminary conclusions – tables and graphs are helpful to show to your audience. The graphic used should show the averaged data. Some questions that might help to think about while preparing this section include: Did you answer your question? Support or disprove your hypothesis? If so, what was the answer? If not, what did you learn?
 - d.** Challenges - Describe challenges you encountered before, during, or after the fieldwork.
 - e.** “What’s Next?” Focus on the following when preparing this section:
 - What are some new questions you have now that you tried to answer your initial question?
 - How might one go about answering one of these new questions?
 - What are some future research projects that could be done with the information that you have discovered?
 - f.** Be prepared for audience questions
- 3.** As noted in the green box, all presentations should be recorded in some manner. All data and presentation materials should also be kept for future use. Students can then refer to these recordings and notes as they format the at home presentations.

Upon returning to the classroom after the expedition the teacher will:

- 1.** Provide students with the materials and recordings from the in the field discussions and presentations. Use these to have students polish presentations.
- 2.** Setup a formal presentation with take holders (parents, other classmates, school board, etc.). This can be used to fulfill the E:Y! community sharing requirement

**Student Experience LESSON:
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Poster or PowerPoint presentations are professional media used by scientists in many fields to communicate their findings to broader audiences (one of the main purposes for conducting scientific research)*. Students need to have the experience in presenting their research formally.

Graphs, charts, etc. should be presented in a clean and professional manner.

Students should add more background research and/or do more processing on the “what next” component of their research.

*A sample of a student-developed poster is included at the end of this lesson.



Examples of Student Research Questions (Page 1):

- 1.** What is the maximum temperature of the different facies?
- 2.** Are all the ponds the same temperature? (If not)What is the range?
 - How are temperatures of different ponds alike and different?
- 3.** How is temperature and color related in travertine?
- 4.** What is the temperature of (where) the aquificales (live)?
- 5.** What is the temperature of the environment where aquificales prefer to live?
- 6.** How are textures and flow rate related in the Apron Channel? Ponds? ProximalSlope? (pick only one)
- 7.** How quickly does the fossilization of insects happen? (this is only possible if two trips to the springs are made)
- 8.** Ephydrid flies:What are the hotsprings conditions where they are most abundant?The problem with this question ended up being that there were no flies present when we arrived at the site, however, they were present at other times.
- 9.** How do the temperatures along aflow path at Narrow Gauge change with distance?
- 10.** How does the temperature affect the colors of the critters (microbes)? How are temperature and colors of critters related?
- 11.** What is the range of temperatures of the waterfalls?
 - What are the colors? (Are their different colors? Are these differences related to temperature differences?)
- 12.** Do the pH levels differ between different facies?
- 13.** How does pH change between different facies?
- 14.** What is the temperature range of the cream streamers' environment?

Examples of Student Research Questions (Page 2):

- 1.** What were the surface temps of the calciteice?
 - This question had to be changed in the field. It was changed to: What was the temperature of the calcite ice, the sunken calcite ice, and the pond without calcite ice?
- 2.** What is the range of temperatures in the calcite foam?
- 3.** What were the color and temperature relationships? (Hypothesis – The (darker or lighter) colors would be warmer than the (darker or lighter) colors.)
- 4.** How does the steam affect the air temperature and humidity X meters away?
 - 2m, 4m, 6m, & 8m
- 5.** What is the minimum distance snow must be away from the hotspring not to melt?
- 6.** How do the temperature difference between water with calciteice and water without compare?
- 7.** How do differences between acidity and temperature in the living environments of microbes in two different hot springs compare?
 - In the Proximal Slope of OSM, and NG, are the acidity and temperature similar for microbial mats of similar colors?
 - What are the pH and Temperature levels of three different colors of microbial communities found?
- 8.** What is the relationship between the pH and the facies along the flowpath?
- 9.** What is the difference between the pH in the vent, ponds, and distal slope facies at OSM?
- 10.** How does the temperature of three different colors (microbes) compare at OSM?
- 11.** How does the temperature of three different colors (microbes) compare at NG?
- 12.** How are temperatures at different locations (Facies) at OSM and NG similar or different?

MICROBE MYSTERIES

BIG QUESTION

Do microbes make darker colors in warmer or cooler water at Orange Mound Hot Spring in Yellowstone National Park?

HYPOTHESIS

We think microbes will make darker colors in warmer water.

PROCEDURE

We looked at a plan on the internet that told us what we needed to do. We looked at a plan that was on the internet. We took pictures of each color water. We took notes on the colors and the temperatures. We took the temperatures of each color of water. We took the temperatures of each color of water. We took the temperatures of each color of water. We took the temperatures of each color of water.

Microbe Hydratus
By:
Cara, Brittany, Michael, Kenyon, and Jess

RESULTS

Black Temps	White Temps	Green Temps	Red/Orange Temps
49	53	55	56
54	64	87	54
57	65	58	59
Average 53.3	Average 60.6	Average 56.6	Average 56.3

- The white color had an average temperature of 60.6 degrees C.
- The reddish/orange color had an average temperature of 56.3 degrees C.
- The green color had an average temperature of 56.6 degrees C.
- The black color had an average temperature of 53.3 degrees C.
- The direction of the proximal slope was 115 degrees South East from the road.

CONCLUSION

Our hypothesis was not supported because the lighter color was in the warmest water.

WHAT WE WOULD DO DIFFERENTLY

Future experiments:

We would try to find how over all the colors, including the black color where we could reach and measure it.

MATERIALS

- Sketch of experiment location
- utilizing
- Grid form
- Pencil
- Infrared Thermometer
- Compass
- Rim for scale measurement
- Fishing pole to hold scale without touching hot springs
- Calculator
- Digital camera with zoom and grid capabilities

HOW THIS APPLIES TO EVERYDAY LIFE

If you went to Yellowstone National Park you would know more about the hot springs and the microbes that live in the hot springs and how hot springs work.