THE EFFECT OF A STEM RESEARCH PROJECTS ON NINTH GRADE

FOUNDATIONS OF SCIENCE CLASSES

by

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of

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In presenting this professional paper in partial fulfillment of the requirements for a Master's degree at Montana State University, I agree that the MSSE Program shall make it available to borrowers under rules of the program.

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ABSTRACT

In this investigation different strategies were implemented for the purpose of determining if students engaged in real world research projects based on their personal interest would find science more interesting. The findings of this project indicated mixed results; some of the data showed little if no difference, and other data, observations and interviews, showed students enjoyed researching projects of their own interest.

INTRODUCTION AND BACKGROUND

For the past seven years, I have been teaching ninth grade freshman science classes at Charles M. Russell High School in Great Falls, Montana. The class is called Foundations of Science (FOS) and is one of three required science courses needed for graduation from the Great Falls Public Schools (GFPS). FOS is designed to give students a solid science background in basic physics, chemistry, and earth science. It also teaches students experimental design techniques through participation in labs, projects and challenges.

Charles M. Russell High School (CMR) is one of two high schools in Great Falls, Montana. It has a student population of approximately 1450 students, 23% whom are registered as free and reduced lunch. Great Falls is a community of 58,000 with 2 high schools, 2 middle schools, and 15 elementary schools. District demographics from the 2012-2013 school year showed there were 3.43% African American, 12.67% American Indian, 1.23% Asian American, 3.43% Hispanic and 78.63% Caucasian (Great Falls Public Schools, 2012).

I have been teaching for 25 years in small rural schools, large city schools, and Native American Reservation schools. This experience of teaching in diverse socioeconomic and cultural environments has exposed me to a wide variety of learning behaviors and has helped me develop more extensive skills and strategies.

Almost every science teacher sooner or later will hear students ask the questions, "Why do we need to know science? When will we ever use this stuff?" Answering those questions seldom satisfies the appetite of those who ask. I tried to get students excited

about science by finding activities, projects, and challenges that pertain to their world. This helped bridge the gap between their world and the world of science.

My school district began an annual STEM (science, technology, engineering, and math) Expo where students could do their own research projects and present them in a formal setting. It is set up much like a science fair with the additional emphasis on technology, engineering and math. In 2012 I began coaching some of my students and helped them set up their own science projects. These students become very interested in their research, as one student said, "I love science now because I am doing something that I am interested in." I then began implementing more significant research projects in my classroom. With the district's emphasis on the STEM process, I thought a STEM Research Project (STEMRP), of the students' choosing, would help students find more interest and confidence in science. This resulted in my first focus question: How does a STEMRP affect student interest in science?

To complete a STEMRP, students would have to be knowledgeable about their subject as well as be very familiar with the experimental process. They would have to learn to develop keen observation, writing, and research skills. Research design is a way students can put their thought processes in an organized and rational manner. This led to my second focus question: How does the use of STEMRP affect student understanding of the scientific process?

In the past I have observed students putting in many hours of their own time when they are asked to work on a project that interests them, but when I asked students how much time was spent studying for a typical summative test, most did not study or spent less than a few minutes reviewing for the test. On occasion when students are working

on projects they are excited about, I have seen them come into class before the bell rings and get started on their work. They also talk about working for many hours over a weekend on their projects. This led me to wonder how much time students would spend on a project of their choosing, one they were passionate about, which led to my next focus question: What effect does STEMRP have on the amount of homework completed?

As a passionate teacher, watching students get excited about learning is a very satisfying experience and is remembered for a life time. Teaching under these circumstances is why I wanted to introduce more students to the research process of science. I wanted students to be excited and passionate about the science they do. The days when I hear students get excited about what they are doing in science class are the days I go home with a smile on my face and a great sense of accomplishment. This led me to my fourth focus question: What impact does STEMRP have on my teaching?

CONCEPTUAL FRAMWORK

Throughout the world United States students are falling behind other students in other countries, especially in the areas of science and math. Even though U.S. students are still considered average in science and slightly below average in math, other countries and regions such as Shanghai and Finland continue to soar upwards in their rankings leaving U.S. students twenty-third (Bybee, 2013). This is a far cry from the 50's and 60's when the United States led the world in these fields and spurred comments like this from the late President John F. Kennedy:

We intend to be first. In short, our leadership in science and industry, our hopes

for peace and security, our obligations to ourselves as well as others, all require us to make this effort, to solve these mysteries, to solve them for the good of all men, and to become the world's leading space-faring nation. (Bybee, 2013)

Much is expected of our science teachers today. They are expected to have their students learn more and more science knowledge by following very broad science standards (Wilson, 2009). According to Bybee (2013) the development of scientific inquiry in science and engineering would contribute to student preparation for the 21st-century workforce. Inquiry science is, according to Wilson (2009), learners engaged in scientific questioning, finding evidence in response to questions, and being able to explain the evidence.

Using inquiry science in the high school science classroom creates much debate among science teachers. With the emphasis on content driven standards, teachers find the more time-consuming inquiry science of little value to students who are required to take content standard tests (Wilson, 2009). Inquiry, however, produces tangible learning outcomes by posing and answering research questions that are relevant to the lives of the students (Colley, 2008). When inquiry science happens, students gain a deeper approach to learning than those students who are more teacher directed (Kemper, 2002). Despite this, teaching content is still emphasized in the standards and benchmarks science teachers are to follow. Just teaching content does not allow students to think outside memorization, but when finding the facts comes from the students own research based on their experimentation, it helps students remember the content as well as develop critical thinking skills that are brought about by inquiry science (Sternberg, 2007). Understanding the content of the subject matter is important but must include the use and

application of that knowledge (Bybee, 2013). Application of content can take many forms including daily hands-on activities, weekly inquiry-based labs or challenges, as well as full research (Harland, 2011). If true scientific inquiry is to be followed then it should follow what is done in the science community. This makes it difficult because most classrooms are not labs (Hanaurer, Jacobs-Sera, Pedulla, Hendrix, & Hatfull, 2006). There are many problems with doing long term research in the classroom. One of the most significant is the lack of research experience of the teacher. If the teacher does not feel comfortable with doing open ended inquiry-based research, they tend to avoid it (Harland, 2011). It is also difficult for many teachers to give up the control of just teaching content. Classroom management is different when students have more control of their learning because they are involved with more than just bookwork or lecture. Student based learning involves observations, proposing solutions, conducting tests, analyzing results, and presenting conclusions (VanDorn and four others, 2005). Even if science teachers cannot implement a complete research based inquiry program, often they can modify their curriculum by narrowing down the focus of student research. This can be done either with short term or long term projects (Harland, 2011).

The recent emphasis on science, technology, engineering, and math (STEM) by many school districts throughout the country has placed more emphasis on inquiry based science. Though STEM is an acronym rather than a learning strategy, it has often used synonymous with inquiry based science in many different forms, including laboratory projects, self-directed inquiry, and scientific inquiry methods (O'Neil, Yamagata, Yamagata, & Togioka, 2012). How much involvement teachers take in their students' inquiry projects, whether open-ended or more guided, plays a role in student learning.

More open-ended inquiry provides students with more ownership, higher thinking skills

and a deeper understanding of how science works (Sedah & Zion, 2012).

METHODOLOGY

The research methodology for this project received an exemption by Montana

State University's Institutional Review Board and compliance for working with human

subjects was maintained. The treatment for this study consisted of 122 students in 5

freshman classes. Students were asked to choose a science topic of their own interest

then design an experiment around that topic. This experiment was developed using the

guidelines spelled out in the STEMRP Guidelines (Appendix A). Each student was given

a copy for their composition books. The STEMRP was conducted over a period of nine

weeks, from January 28, 2013, to March 23, 2013. Two days per week, Thursdays and

Fridays, were dedicated as class time to work on the STEMRP. The reason for spreading

out the STEMRP was to allow students who were doing long term research, such as

growing plants, more time to complete their research. This classroom time was used for

students to work on their projects, planning, journaling, data collection, and preparation

for their presentations. It was also a time when I could coach students on problems they

were having, as well helping them with some of the finer details of their research. Any

additional time needed was on the students' own time. During the last week, students

were given three extra classes to put the final touches on their projects and presentations.

Students were given the choice of working on their own or with another student.

If they chose a partner, both were required to write their own paper. They could use the

same data sets and pictures, but all other writing, including their own composition books, had to be done and handed in on an individual basis. They were required to have a composition book dedicated to their STEMRP.

Prior to conducting their experiments, students were given the Metge Pre-STEM Research Project Survey and the Metge Experimental Design Pre/Post Test (Appendix B and C). The Metge Pre-Stem Research Project Survey was a five question survey which helped establish a baseline for students' motivation and confidence in science prior to completing their STEMRP. These questions asked students how they liked science and then to share what parts of the science class they found most interesting. The survey was set up following a Likert-style, but each answer was worded rather than numbered to help students understand the purpose of the question. At the completion of STEMRP, the Metge Post-STEM Research Project Survey was given which included the same questions as the Metge Pre-STEM Project Survey with the addition of three questions that were not comparison questions and could only be asked at the end of the research project (Appendix D). These questions asked students the amount of time they spent on STEMRP homework, how much homework they did for the regular science part of the class, and if they felt the STEMRP increased their confidence in learning science. At the end of the STEMRP questions on the pre and posttest were compared to see if students' interest and confidence in completing a science research project had improved.

Before students began their STEMRP, they were also given the Metge Stem Research Project Pre and Post Test. This 17 multiple choice pre-test assessed student understanding of the technical aspects of research design, including definitions, hypothesis design, establishing variables, and other components of a research project. At

the end of the project, the same test was given as a post-test, and the data were compared

to help analyze how well STEMRP affected student understanding of the scientific

process.

At the beginning of the project students were given the STEMRP Due Dates and

Grade Check form, and they were asked to permanently attach it to the inside front cover

of their composition books (Appendix E). This was their guide to help them know when

different parts of the project were due and to help them keep track of their grades as they

progressed through the project.

In the first week students were given Brainstorming Ideas for the STEMRP, this

handout, along with classroom discussion, helped guide students in selecting their own

research topic (Appendix F). Computers were used to research their topics, to collect

background information, and to help the students decide if their topic was testable. After

they selected their topic, students were given Metge STEMRP Design Table that guided

students through designing their project using both classroom discussion and individual

instruction (Appendix G). They selected their independent variable and determined how

they were going to manipulate it. Based on their research, they predicted what would be

the dependent variables. On this handout they also established a control, if it was

applicable, and listed all of the constants they needed to be aware of. Their experimental

data sets were also established and described at the bottom of the handout.

Hypothesis design was studied in the second week. The STEMRP approach to

writing a hypothesis was to have students understand that a hypothesis should state the

independent variable and its effect on the dependent variable. Students are also

encouraged to state their reasoning why they thought their hypothesis would work. After

discussing what makes a good hypothesis, students were given Writing a Hypothesis for the STEMRP (Appendix H). At the completion of this handout, students came up with a strong, testable hypothesis for their STEMRP.

With the completion of their literature research, experimental design and hypothesis, students wrote and submitted a research proposal for teacher approval. This was done in the form of a business letter, STEMRP Sample Proposal Letter (Appendix I). The student's proposal, using their background research, had to show they understood their topic, had a testable hypothesis and a clear workable procedure. Any tools and materials were also to be specified and how they were to get them if they were not readily available. Students were not allowed to continue their project until the proposal was approved by the teacher. If it was not approved, they were required to go back and make the suggested corrections and resubmit or think of a new project.

During the third week, students were instructed on organizing and using a lab notebook. It was required they use a composition style book. In the composition book they kept all of their information pertaining to the STEMRP. This week, providing their proposal was approved, was also the week students started on their experiments. Students could bring their experiments into the classroom, or they could work on them at home. Either way they needed to keep their science composition books and class work updated. Keeping a log or journal was of vital importance. Entries were to include the date of entry, what they did, data collected, and any observations they made. It was also required to have a picture of their experimental progress, and it needed to include at least one picture of the student while they were doing their work.

Composition books were checked every two weeks using the STEMRP Composition Book Grading Rubric (Appendix J). Students were to keep daily logs of their experiment, diagrams, pictures, journal entries, and data tables. They were also to keep a time log showing the amount of time they worked on their projects in class as well as outside class. This data were then used to compare the amount of time students worked on their STEMRP to regular homework. Students were also encouraged to write down their mistakes and any corrections they made during the experimental process. The composition books were to be present during their presentations and could be used as a reference when asked questions by judges and/or other students.

For weeks four, five, and six, students continued to add data, write in their journals and make observations. On week seven students were given additional instructions on writing their formal research papers and help on their mode of presentation. Those students attending the STEM Expo were required to have a poster of their work and props to help show the judges and patrons of the Expo what their project was about. Those students not finished with their experiments left their data sets blank. A rough draft was first completed and peer edited using the STEMRP Peer Editing Rubric (Appendix K). Peer editing was not as rigorous grading as I would do, but it was designed to help students find some of the more obvious technical and formatting errors. Students were encouraged to have parents or family members edit their papers to help with their involvement in the project.

The STEMRP Grading Rubric (Appendix L) was given to students prior to the start of the STEMRP so they could use it as a guideline. This was the rubric I used to grade their STEMRP. After corrections were made from the peer editing, the final paper

was written and submitted prior to their presentation in class or at a symposium. Students

were given the opportunity to make corrections to their final papers if they wanted a

better grade.

Upon completion of the STEMRP, students who did not attend the STEM Expo

had to present their projects in the class. The same criteria were used to grade their

presentations as were used during the Great Falls Public Schools STEM Expo (Appendix

P). At the completion of their presentations, they were asked questions from their peers.

Students were also asked to complete the Metge Post STEMRP Survey (Appendix M). A

random selection of 16 students were chosen from the roster and interviewed by the

teacher using the Metge STEMRP Interview Questions (Appendix N).

Each year the Great Falls Public Schools requires all science classes to give a

Foundations of Science District Performance Assessment (Appendix O). This

assessment evaluates students' ability to design and write an experiment. In this

assessment students were given an effervescent tablet and asked to design a reaction time

experiment within the given parameters. There is a two day time frame for students to

complete this test. After completion, tests are graded using the Great Falls Public

Schools Foundations Rubric Checklist (Appendix P). These scores were then compared

to the 2011 year's scores to see if the STEMRP affected student ability to understand and

implement the scientific process. The 2011 year was chosen because this was the first

year this test and rubric was used. In 2012 this test was improved by a committee of

science teachers; however in 2013 the district office made a mistake, which I did not

catch, and gave me the 2011 test. To remain consistent, I used the data from the 2011

test and compared it to 22 randomly selected tests from my 2013 students. The names of

the students were folded over and taped down. This was done by the students before

handing in. The tests were left in the same order they were collected, I then selected 4 or

5 tests from each class.

During the nine week STEMRP, I kept a log where I wrote down observations I

made of my students as well as ideas about how I could improve on the STEMRP the

following year. I also wrote down how I thought the project was going and how this

STEMRP affected me as the teacher.

Table 1
Research Focus Questions

Research Focus Questions	Data Source					
	Student Survey	Student Interview	Experimental Design Test	District Performance Assessment	Student Science Composition Book	Teacher Journal
How does the use of STEMRP affect student interest in science?	X	X				X
What effect does STEMRP have on my teaching?			X	X	X	X
What effect does STEMRP have on the amount of homework completed?	X	X			X	
How does STEMRP impact my teaching?	X	X				X

DATA AND ANALYSIS

At the completion of the STEMRP, data collection from the Metge Pre and Post-STEM Research Project Survey ($N = 74$) that asked, "How would you rate your interest in science?" showed a decline of 2.3% in students' interest in science (Figure 1). Additional data from the Metge Post-STEMRP Survey, however, showed when students were asked, "Did the STEMRP affect your attitude positively towards science?" 9.3% said it was strongly affected positive and 26.7% said positive, for a total of 36% responding positively (Figure 2). From the STEMRP Interview Questions ($n = 16$), when students were asked, "If you could choose, would you rather be doing classwork or working on your STEMRP?" 69% of students said they would rather be doing their STEMRP than classwork (Figure 3).
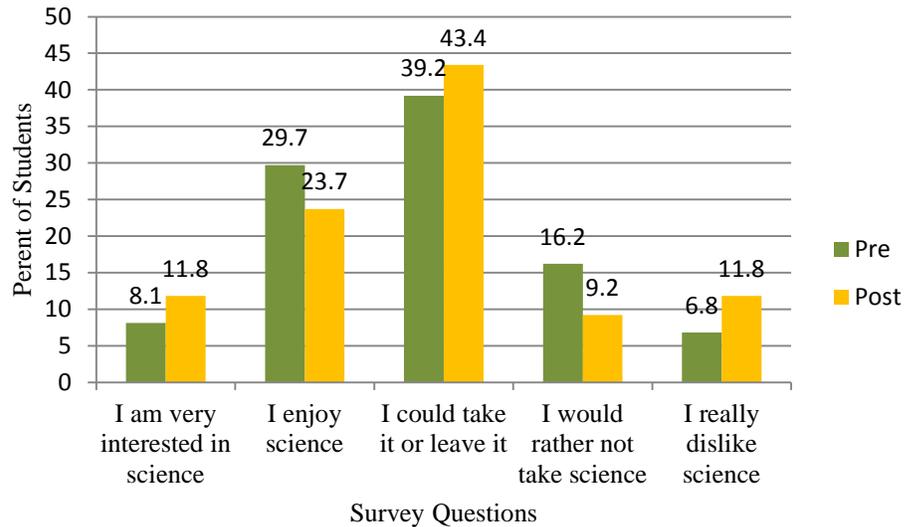
Figure 1. Metge research project survey, ($N = 74$).
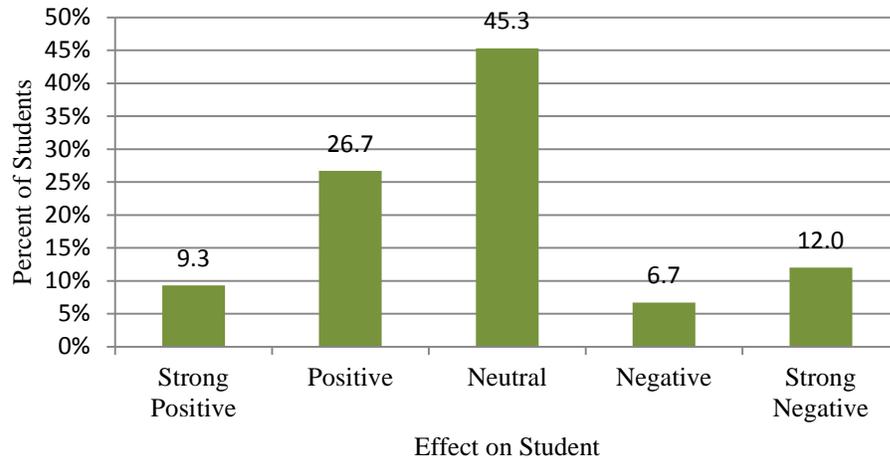
Figure 2. How did the STEMRP affect your attitude towards science?
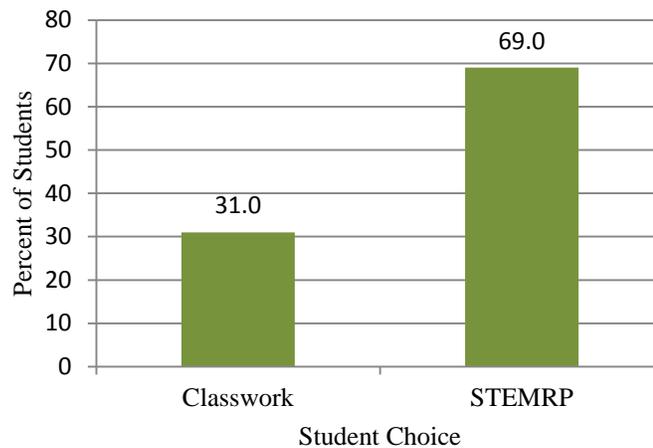
Figure 3. Student choice of classwork or STEMRP, (*n* = 16).

Data collected from the District Foundations of Science Performance Assessment in 2011 showed that students scored an average of 73% (*N* = 22). These data were taken from my Foundations of Science class only. The same test given in 2013 after students finished their STEMRP, showed students with an average score of 90% (*N* = 22) (Figure 4). Students taking the Metge Experimental Design Pre/Post Test, however, scored on average 34.4% on the pre-test and 35.5% on the post-test. From the STEMRP Survey,

75% of students said their knowledge of science increased upon completing the

STEMRP.
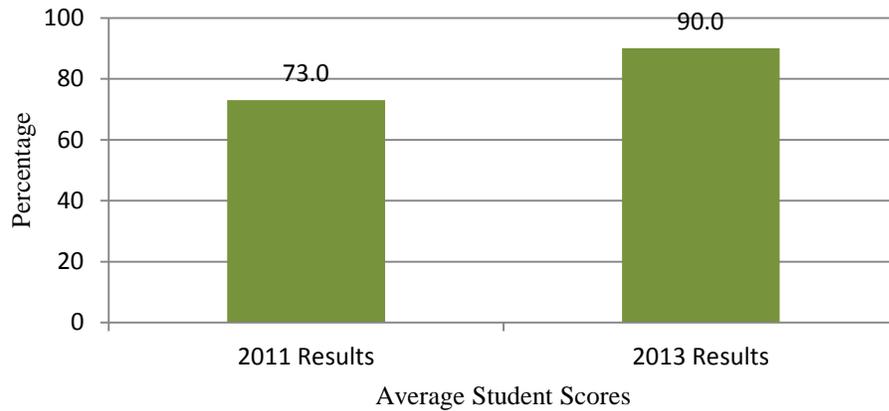
Figure 4. Student results from the District Foundations of Science Performance
Assessment, ($N = 22$).

Students were asked, prior to starting on the STEMRP, to rank their preferred

science learning activities. Only 25.6% chose large research projects, such as the

STEMRP, as their first choice compared to 54.7% choosing labs and experiments. After

completing the STEMRP, 25% chose the large research projects first compared to 60.5%

choosing labs and experiments (Figure 6).
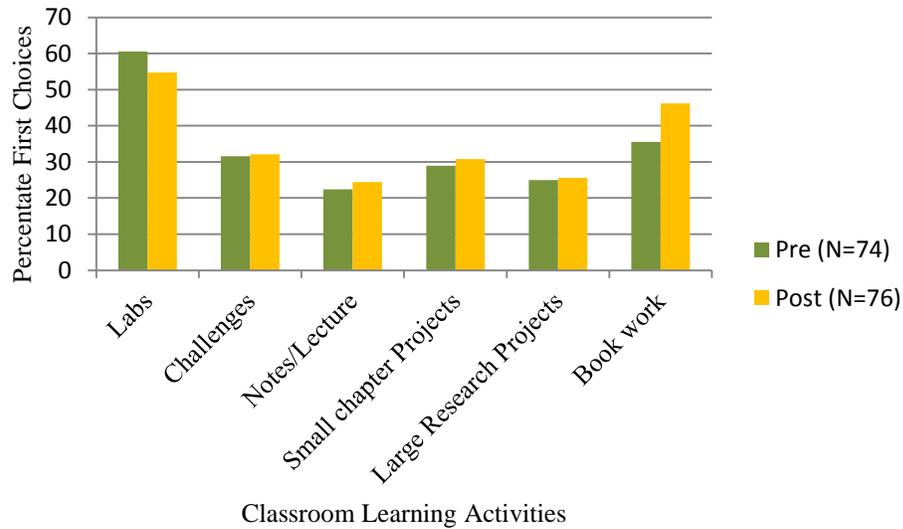
Figure 5. Student ranking of learning strategies, (*N* = 74).

Over the nine weeks of the STEMRP, 58.7% of the students said they spent two

hours or less on regular science homework (Figure 7). During the same time, however,

27.3% said they spent over 10 hours of homework on their projects and 50.7% spent

between 3 and 10 hours. These hours do not reflect the 32 students who participated in

the Great Falls Public Schools STEM Expo, which was held on Saturday, April 23, 2013.

Students were required to be there for four and a half hours.
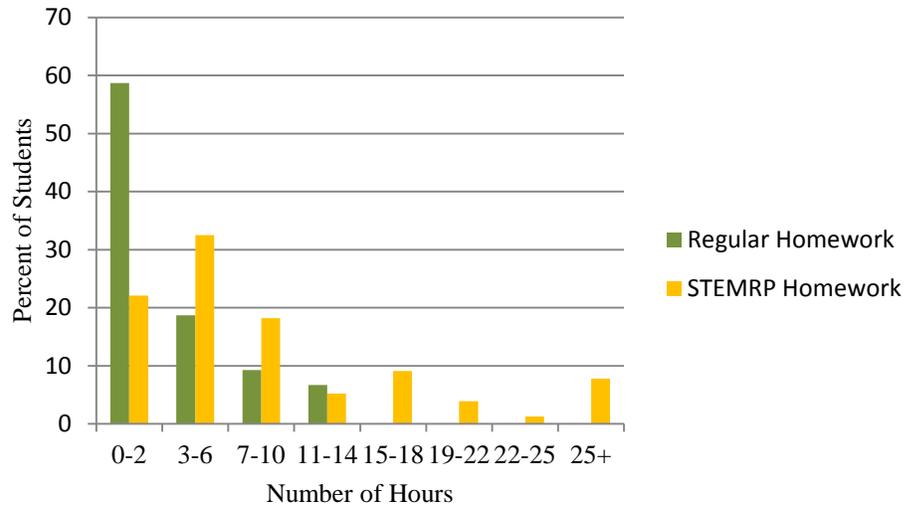
Figure 6. Time on homework comparison, (*N* = 74).

INTERPRETATION AND CONCLUSION

The results of this study were analyzed to answer my focus questions. The first

focus question was: How does the use of the STEMRP affect student interest in science?

The student pre and post survey showed a decline of 2.3% for this question. The survey

was given directly after completion of the STEMRP which may have led to the decline of

interest because students were tired of the STEMRP and wanted to move on to something

different , however when students were asked, How did the STEMRP affect your attitude

towards science?, 38% of the students responded with a strong positive or positive. The

2.3% decline in student interest also conflicted with students responses when asked if

they would rather be doing classwork or the STEMRP. This question showed 69% of

students would rather be doing their STEMRP. When students were asked in the

interviews to explain why, numerous students said, "It was hands on." Another student

said, "I have control of my learning." while another said, "I wanted to know what the

results of my project." I believe some of the differences could be attributed to the wording of the questions. The first question about student interest gave students five response choices. The next question about doing STEMRP or classwork in the class, gave students only two response choices. In analyzing this data I also realized students may find the STEMRP to impact them positively but still not affect their interest in science.

The next focus question was: How does the use of STEMRP affect student understanding of the scientific process? The first data source was the Metge Experimental Design Test. This test was given as a pre and a post test. The results of the data were inconclusive. Students' average scores were 39% on both the pre and posttest. Upon analyzing the results of the posttest, I knew that something was wrong. I reviewed the test and found it was very poorly written; therefore I did not use this data.

The District Performance Assessment did show students improving in the knowledge of the scientific process by 17%. When I was explaining the district assessment to my students, one student said, "After doing the STEMRP the district assessment will be a piece of cake." My observations also showed numerous students expressing pride in their work and many of them expressing a desire to do the STEM Expo next year.

Students put far more homework time into the STEMRP than they did for the regular class homework. This answered my next focus question which asked, Does STEMRP affect he amount of homework done by a student? Over the nine week period none of the students put in more than 11-14 hours on class homework, however 30% of students put in this amount or more into their STEMRP homework.

Some of the positives that students expressed about the STEMRP were: choosing their project subject, working with friends, presenting at the STEM Expo, and pride in their work. Some of the negatives, however, were taking too much time, their poor organization skills, too much work, and giving up of their free time on weekends.

VALUE

I thought about my own process through the MSSE Capstone and realized how tired I was at the end of the project. If I had been given a survey immediately after completing my MSSE capstone asking me if I would rather do a regular class or write my capstone, I would have chosen to take classes, even worksheets. I do not think my feelings were much different than those of my students. When I gave the post-survey and post-test they were exhausted and were glad it was over. At this time they did not really care about their STEMRP, yet by the end of the week, when I interviewed them, they gave more positive comments. When I asked one student what the most positive aspect of the STEMRP was he replied, "It's the pride, Mr. Metge, I feel very proud of what I did." A few weeks after the STEM Expo, students received medals for their achievement. As students came into class they were beaming and wearing their medals proudly. Some even wanted to have their pictures taken together. I also overheard a couple of students saying they wanted to do the STEM Expo next year. So most students thought it was a good experience even though some data did not support this.

There are a number of things that I should have done differently and will implement them next year. Even though students liked the ability to choose their own

topics, it was also frustrating for them. They come to my class with very limited background knowledge, so many of them thought the possibility of doing a demonstration was all the needed to do. One of the interview questions asked them what I, as the teacher, could have done differently. Many students wanted more guidance on choosing their topic. Next year I plan to spend more time developing testable ideas. This will be done by guiding them through what makes a good experiment and give many good examples for them to choose from. I will also give them more time to explore websites such as sciencebuddies.com. At the end of this school year I applied and received a grant for 22 new probes and sensors for my Vernier LabQuests. Digital equipment such as this often excites students about doing science experiments because it uses technology.

Another area of development is using people who are experts in the field the students want to study. This could be parents, relatives, friends or others in the community. One of my student's experiments was the effect of magnetism on bacterial growth. Her mother worked in a lab at the hospital and was allowed to use some of the equipment there. It was a very interesting experiment.

Even with the mixed results I will continue to do the STEMRP each year with my students. I will continue to improve my presentation and work out the weaknesses of the program. Despite some of the data, I am encouraged and do believe that in years to come students will remember doing their STEMRP more than anything else in my Foundations of Science class. When their children take high school science, they will tell them about doing their research project in freshman science class, not the PowerPoints or textbook work.

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APPENDICES

APPENDIX A

STEMRP GUIDELINES

STEMRP Guidelines

In your Foundations of Science (FOS) class you are required to complete a STEM Research Project (STEMRP). This project will challenge you but because you get to choose your topic, you should find it very interesting. I promise if you do your best and complete all of the sections of this project, you will feel a real sense of accomplishment and be proud of the work that you do.

At the end of the STEMRP you will be able to:

✓ Choose and research a topic in science that you are interested in.
✓ Design an experiment with an independent variable (IV) you can manipulate.
✓ Accurately predict the response of the IV on the dependent variables (DV).
✓ Write, develop and implement a scientifically sound research project based on a well-researched and written hypothesis.
✓ Collect reliable data using tools best suited for your experiment.
✓ Write a STEM research report.
✓ Present your STEMRP to your peers and/or judges as required.

Mr. Metge

Foundations of Science Teacher
Charles M. Russell High School
Great Falls, Montana

APPENDIX B

METGE PRE-STEM RESEARCH PROJECT SURVEY

Metge Pre-STEM Research Project Survey

1. How would you rate your interest in science?
    - o I am very interested in science
    - o I enjoy science
    - o I could take it or leave it
    - o I would rather not take science
    - o I really dislike science

2. Which of the following science classes would you find interesting to take? (You can choose more than one)

    ____ Physics   ____ Chemistry   ____ Biology   ____ Astronomy

    ____ Geology   ____ Botany   ____ Forensics

    ____ Environmental Science   ____ None

3. Regardless of how you feel about science classes, rank your interest for each of the learning strategies. Number one being your most favorite.

    ____ Labs/Experiments
    ____ Challenges
    ____ Notes/Lecture/PowerPoint
    ____ Small chapter projects
    ____ Large research projects (STEM Expo, Science Fair)
    ____ Book work/worksheets

4. Do you plan to take more than the required three science classes before you graduate?

    ____ Yes   ____ No   ____ Maybe

5. Think about your favorite class or classes. What are the main reasons you like that class? (Rank in order of most importance to you, one being the most important)

    ____ The teacher
    ____ The subject content
    ____ The work load (less being better)
    ____ The work load (more being better)
    ____ What I learn
    ____ The other students in class
    ____ The time of the day

APPENDIX C

METGE EXPERIMENTAL DESIGN PRE/POST TEST

Metge Experimental Design Pre/Post Test

Name _____ Date _____ Per _____

1. What are the main components of an experimental design? (enter all that apply)
    a. Hypothesis
    b. Variable
    c. Trials
    d. Inference
    e. Experimental groups
    f. Scanning microscopes
    g. Control groups
    h. Samples
    i. Notebooks
    j. Constants
2. What is the purpose of having a hypothesis in a STEM-based research project?
    a. To be able to make an educated guess.
    b. To formulate what you want to test and define the limit of your experiment.
    c. To be able to replicate the experiment if it does not work.
    d. To determine how changes within the experiment will be measured.
3. Why is it important to do background research on independent and dependent variables?
    a. Background research should help determine which dependent variables are most likely to show change in time.
    b. It tells you if it is worth doing and give the answers to your hypothesis.
    c. It help you determine if the independent and dependent variables backwards.
    d. Background research is not always necessary because you may have enough experience and knowledge to forgo this part of the experimental process.
4. What are experimental groups?
    a. Group that you apply the different independent variable too.
    b. These are the different partners in your group.
    c. They determine if the dependent variable have validity
    d. These are treatment groups that receive all of the same conditions except the varying amounts of the independent variable.
5. How are constants different than controls?
    a. Control groups are factors that are kept the same and constants are the one group all others are compared.

     b.   Constants don't change where control groups are what you manipulate.

     c.   Control groups are the one group all other groups are compared to and constants are factors that are not changed.

6. Quantitative date is that which can be expressed in descriptive ways.
   a. True
   b. False

7. Mark those observations that would be considered qualitative data.
   a. $110^{\circ}C$
   b. 62 segments above the clitellum
   c. Worm pink at the posterior end and brown everywhere else
   d. Color of the water did not change with the addition of water
   e. 40 min
   f. 2.1 g
   g. Cord made a loud cracking sound before it snapped.

8. An inference is a conclusion, based on facts, that is perceived to be false by the researcher.
   a. True
   b. False

9. A tentative and testable proposed explanation for an observable phenomenon. (answer the question with the correct spelled term)

10. The factors within an experiment that are kept the same for all groups or trials. (answer the question with the correct spelled term)

11. At what point of the experimental design should you write the hypothesis
   a. As soon as you chose an entity
   b. When you have completed most of the experiment and you have a good idea what the results will be.
   c. After you do your preliminary background research but before the experiment begins.
   d. Anytime during the experiment.

12. Given the statement, "Temperature has an effect on crickets', what part would you develop the dependent variable from?
   a. The crickets
   b. Temperature
   c. Cricket noise
   d. Not enough information to determine

13. Given the statement, "The performance of various gasoline octane levels (87/90/91) differs", what part would you develop the independent variable from?
   a. The size of the engine
   b. Octane levels
   c. Performance

d. Not enough information to determine

14. Essentially, your introduction is a paper written by you to show your teacher (check all the correct reasons)
    a. What the title of your project is
    b. You understand the background of your topic
    c. The results of your experimentation
    d. You have a testable hypothesis
    e. You have an appropriate procedure
    f. You have an entity

15. Is it necessary to do a pretrial?
    a. Yes
    b. No

16. Good scientific writing should be (check all you think are correct)
    a. Wordy
    b. Technical jargon
    c. Concise wording
    d. Surveys or questionnaires
    e. Accuracy
    f. As few a words as necessary

17. What are appendixes and where do they belong?
    a. A tube-shaped sac attached to and opening into the lower end of the large intestine in humans and some other mammals.
    b. Large table, graphs, surveys at the end of your paper
    c. The collection of all of your data in a concise table
    d. Similar to writing a paper English class but it's actually for science class.

<u>APPENDIX D</u>

METGE POST-STEM RESEARCH PROJECT SURVEY

Metge Post-STEM Research Project Survey

1. How would you rate your interest in science?
   - o I am very interested in science
   - o I enjoy science
   - o I could take it or leave it
   - o I would rather not take science
   - o I really dislike science

2. Which of the following science classes would you find interesting to take? (You can choose more than one)

   ____ Physics ____ Chemistry ____ Biology ____ Astronomy

   ____ Geology ____ Botany ____ Forensics

   ____ Environmental Science ____ None

3. Regardless of how you feel about science classes, rank your interest for each of the learning strategies. Number one being your most favorite.
   - ____ Labs/Experiments
   - ____ Challenges
   - ____ Notes/Lecture/PowerPoint
   - ____ Small chapter projects
   - ____ Large research projects (STEM Expo, Science Fair)
   - ____ Book work/worksheets

4. Do you plan to take more than the required three science classes o graduate?

   ____ Yes ____ No ____ Maybe

5. All year you have been using a Science Composition Book. Please rate the value of this tool in your science class. I am not interested in whether you liked it or not, I want to know if you found in helpful.
   - ____ It was a big help
   - ____ I found it helped some what
   - ____ More of a hassle than an benefit
   - ____ Total waste of graphite and paper

6. Over the past 8 weeks, approximately how many hours did you work on your STEM Research paper outside of class?
   - ____ 0 -2 hours
   - ____ 3 - 6 hours
   - ____ 7 – 10 hours
   - ____ 11 – 14 hours
   - ____ 15 – 18 hours
   - ____ 19 – 22 hours
   - ____ 22 – 25 hours
   - ____ 25+ hours

7. Over past 8 weeks, approximately how many hours did you work on your science homework, not including the Stem Research Project?

> ____ 0 -2 hours
> ____ 3 - 6 hours
> ____ 7 – 10 hours
> ____ 11 – 14 hours
> ____ 15 – 18 hours
> ____ 19 – 22 hours
> ____ 22 – 25 hours
> ____ 25+ hours

8. How did the STEM Research Project affect your attitude towards science?

> ____ Strong positive
> ____ Positive
> ____ Neutral
> ____ Negative
> ____ Strong negative

APPENDIX E

STEMRP DUE DATES & GRADE CHECK LIST

STEMRP Due Dates & Grade Check List

Name _____ Partner _____

Research Title _____

To Be Completed	Due Date	Date Completed	Grade
Handout #1 Brainstorming Ideas			
Handout #2 Background Research Questions			
Handout #3 Practicing Writing a Hypothesis			
Research Proposal			
Organize Laboratory Notebook			
Start Experiment			
Data Collection Check (Photos, Notebook, Tables)			
End Your Experiment			
Data Collection Check (Photos, Notebook, Tables)			
Rough Draft of Research Paper			
Handout #4 Form for Peer Editing of STEM Research Paper			
Submit Final Research Paper			
Classroom Presentation or Outside of Classroom Presentation			
Review Classroom Presentations by Other Students			
Complete Poster			
Participate in Real Symposium Presentation (Science Fair, Expo, etc.)			

APPENDIX F

BRAINSTORMING IDEAS FOR THE STEMRP

Brainstorming Ideas for the STEMRP

Name _____ Partner _____

What do you want to study? What are you passionate about? What can you study that will make a difference? What are some common misconceptions I could test? (List as many topics as you would like)		
What could I manipulate or how could I change my subject and make it into a testable experiment?	What could I measure, using numbers, to record the responses of what I changed?	
What materials do I need to complete this experiment? Are they available? Where can I get them?	What tools or skills will I need?	Do I need outside help? Who can I get to help?

APPENDIX G

METGE STEMRP DESIGN TABLE

METGE STEMRP Design Table

Name _____ Partner _____

Proposed Research Title _____

Proposed Hypothesis (Underline IV once and DV twice)			
What is your proposed Independent Variable (IV)?	How can you manipulate (change) the IV so you can collect valuable data?		
Describe or predict what your data will look like (DV) based on your research.	Now separate this data into calculated data and descriptive data	List Quantitative Data (calculated data)	List Qualitative Data (descriptive data)
List things that you should not change (constants).			
What will you compare your experimental groups too? (control)	Exp. Group #1	Exp. Group #2	Exp. Group #3	Exp. Group #4

APPENDIX H

WRITING A HYPOTHESIS FOR THE STEMRP

Writing a Hypothesis for the STEMRP

Name _____ Date _____ Per ___

Your hypothesis is a statement not a question! You are predicting what will happen. Do not use I think!

Some sample formats you can use;

1. If the Independent Variable (IV) is related to the Dependent Variable (DV), then (make prediction).
2. If the (IV) is (describe changes), then the (DV) will (make prediction).
3. (DV) will (predict the effect) when (IV) (describe changes).

Make sure your hypothesis is testable. In other words your hypothesis should make it clear how you are going to test it by connecting the IV to the DV.

What is your IV?   _____

What is your DV?   _____

What changes will happen to your DV when you change the IV?

_____

_____

_____

Now put them together in one of the three formats listed

above:_____

_____

APPENDIX I

STEMRP SAMPLE PROPOSAL LETTER

STEMRP Sample Proposal Letter

1515 Central Ave NW
Great Falls, MT 59404

March 3, 2013

Mr. Murray Metge
Foundations of Science Teacher
Charles M. Russell High School
228 17th Street NW
Great Falls, MT 59404

Dear Mr. Metge:

STEM Research Project Proposal

The title for my STEM Research Project (STEMRP) is the Effect of Bokashi Tea on the germination rate of different garden seeds. Bokashi Tea is derived from composting household organic matter using an anaerobic process. Compost from the kitchen will be collected in a five gallon container and a compost accelerant will be added to speed up the process of decomposition.

The accelerant to be used is called Bokashi and is made of all natural ingredients, including wheat bran, filtered water, EM-1 and molasses. The process will be done in a five gallon bucket placed in the kitchen. As the compost decomposes a liquid tea, rich in microbes, is produced. This tea will be drained off and diluted in various concentrations. Each concentration will be soaked in a paper towel and seeds will be placed in the paper towel.

The hypothesis for this STEMRP will be; If Bokashi Tea is high in nutrients then it will enhance the germination rate of vegetable seeds.

The materials needed for this experiment will be household compost, a sealable five gallon bucket with spout, Bokashi accelerant, bowls, paper towels, different seeds, and water. No safety warnings were researched as this is an all-natural process. The Bokashi accelerant can also be used directly in the plant soil, kitty litter boxes and septic systems.

The time frame of this experiment will be approximately two weeks for the compost to decompose and another week or two for seeds to germinate. Results will be logged on a daily basis in the science composition book.

Sincerely,

Fred Winslow
Foundation of Science Student

Enclosures (1) Experimental Design Table

APPENDIX J

STEMRP COMPOSITION BOOK GRADING RUBRIC

STEMRP Composition Book Grading Rubric

Name _____ Date _____ Per _____

	Student Score	Teacher Score
Composition book is neatly organized, with dates and headings.		
Composition book has all current notes including dates.		
Composition book has all data tables and observations.		
Composition book has complete journal entries for each day project was worked on.		
Max 5 points each – Max total 20 points **Total**		

APPENDIX K

STEMRP PEER EDITING GRADING RUBRIC

STEMRP Peer Editing Grading Rubric

STEMRP Title _____ Date _____ Per

_____

Author _____ Editor

_____

Component to grade	Peer Evaluation Score range 0-10, 10 being the best. Feel free to make comments here.
Does the <u>title</u> express the IV and DV?	

Do you think the <u>Introduction</u> is complete?
   Does it explain what the project is about?
   Are there any first-person pronouns?
   Do they have at least two citations?
   Is the hypothesis clearly stated?	

Is the <u>materials and methods</u> complete?
   Could you repeat the experiment from this section?
   Is there a photo or drawing showing how data was collected?	

Are the <u>results</u> clear and concise?
   Are the tables clearly labeled including correct units?
   Are all figures and tables referenced properly?
   Are there any opinions or judgments? (put line through if so)	

Does the <u>analysis</u> and <u>conclusion</u> sum up the STEMRP?
   Is there a statement whether the hypothesis is supported?
   Does the author compare results to the control?
   Are possible errors clearly addressed?
   Are there suggestions made for additional research?
   Is the documentation correctly sighted?	

Is the works cited correct and complete?	

Is the paper free of spelling and grammatical errors?
   Is the paper double spaced?
   Is the paper written in 12pt font?
   Does the type look like it is Times New Roman or Ariel?	

Comments: (make constructive comments here to help the author make a better paper)	

APPENDIX L

STEMRP GRADING RUBRIC

STEMRP Grading Rubric

Name _____ Partner _____

Project Name _____ Date _____ Per ___

INTRODUCTION	5	3	0
Problem Described	Problem is described using background research and explaining why the need for current research.	Description is weak and/or poorly documented.	Problem is not described.
Materials & Methods	Detailed description of procedures so others can replicate. Includes all materials and diagram or photograph depicting setup.	Description missing details and/or materials not complete.	Description mission critical details.
Graphical Representation of Data	All figures and tables are named and numbered correctly with proper units and labels.	Some missing parts and/or poorly organized.	Many parts mission including any of the units necessary.
Documentation	Correctly formatted citations including proper work cited.	Two to three errors.	More than three errors.
Spelling and Mechanics	Proper spelling and mechanics throughout the paper.	One or two errors.	More than two errors.
Content	Content is relevant and in depth, showing author understand purpose of research and makes good conclusions based on data and research.	Some relevance but lacking clarity in writing.	Lacking the research and data. Shows the author put little or no time into project.
Total			

APPENDIX M

METGE POST STEMRP SURVEY

Metge Post-STEMRP Survey

1. How would you rate your interest in science?
    - o I am very interested in science
    - o I enjoy science
    - o I could take it or leave it
    - o I would rather not take science
    - o I really dislike science

2. Which of the following science classes would you find interesting to take? (You can choose more than one)

3. ____ Physics   ____ Chemistry   ____ Biology   ____ Astronomy
    ____ Geology   ____ Botany   ____ Forensics
    ____ Environmental Science   ____ None

4. Regardless of how you feel about science classes, rank your interest for each of the learning strategies. Number one being your most favorite.
    ____ Labs/Experiments
    ____ Challenges
    ____ Notes/Lecture/PowerPoint
    ____ Small chapter projects
    ____ Large research projects (STEM Expo, Science Fair)
    ____ Book work/worksheets

5. Do you plan to take more than the required three science classes o graduate?
    ____ Yes   ____ No   ____ Maybe

6. All year you have been using a Science Composition Book. Please rate the value of this tool in your science class. I am not interested in whether you liked it or not, I want to know if you found in helpful.
    ____ It was a big help
    ____ I found it helped some what
    ____ More of a hassle than an benefit
    ____ Total waste of graphite and paper

7. Over the past 8 weeks, approximately how many hours did you work on your STEM Research paper outside of class?
    ____ 0 -2 hours
    ____ 3 - 6 hours
    ____ 7 – 10 hours
    ____ 11 – 14 hours
    ____ 15 – 18 hours
    ____ 19 – 22 hours
    ____ 22 – 25 hours

_____ 25+ hours

8. Over past 8 weeks, approximately how many hours did you work on your science homework, not including the Stem Research Project?

     _____ 0 -2 hours
     _____ 3 - 6 hours
     _____ 7 – 10 hours
     _____ 11 – 14 hours
     _____ 15 – 18 hours
     _____ 19 – 22 hours
     _____ 22 – 25 hours
     _____ 25+ hours

9. How did the STEM Research Project affect your attitude towards science?

     _____ Strong positive
     _____ Positive
     _____ Neutral
     _____ Negative
     _____ Strong negative

APPENDIX N

STEMRP INTERVIEW QUESTIONS

STEMRP Interview Question

1. Explain to me what is expected of you in doing the STEMRP.

2. If you chose would you rather be doing classwork or working on you STEMRP? Explain why.

3. Do you find science more interesting because of your STEMRP? Explain.

4. Did the STEMRP help you in your knowledge of science?

5. What was your most positive aspect of the STEMRP?

6. What was your most negative aspect of the STEMRP?

7. If you were the teacher, what would you do different concerning the STEMRP?

8. Is there anything else that you would like to share with me concerning this STEPRP?

APPENDIX O

FOUNDATIONS OF SCIENCE DISTRICT PERFORMANCE ASSESSMENT

Foundations of Science District Performance Assessment

Day 1: Observe, Question, Predict

Purpose: You will make observations of a chemical reaction, write a

question, and propose a hypothesis to test for tomorrow. You have 4 tasks to

complete today.

Prompt: There are many variables that affect reaction time.

Materials List: You have the following materials to test this prompt.

>   Antacid Tablets
>   Cup
>   Access to warm and cold water
>   Digital Balance
>   Water Measuring Tool
>   Stop Watches
>   Thermometer
>   Spectrum of tools in the classroom
>   Hammer
Ruler

Task 1: Observations: You will be given an antacid tablet, cup and water.

Make and record qualitative and quantitative observations of the reaction.

Task 2: Question: Record one question below that is testable and relates to the

prompt and your observations.

Day 2: Design, Conduct, Analyze, Communicate

Purpose: Today you will design and experiment (fair test) to test your

hypothesis from Day 1. You have 7 tasks to complete.

Task 4: Use Variables

- List the independent and dependent variable you need to consider in ou
  experiment.
- Identify control variable to design a far test (controlled experiment).

Task 5: Write Procedure

Write a repeatable procedure for testing you hypothesis. Include tools, materials, and processes or techniques that make this a fair test (controlled Experiment).

Task 6: Organize Information

Construct a neat, complete data table in the space below to record you data. Make sure you include a title and labels.

Task 7: Conduct Experiment to observe, measure, and record

Conduct your experiment. Collect and record you data in the data table you have constructed above.

Task 8: Begin analysis by making a graph

Construct a neat, complete graph of your data on the graph paper below.

Task 9: Made sense of the data by inference and pattern analysis

Answer the following prompts to summarize what you have learned.

a. Describe the status of your hypothesis
b. Explain the answer to the question you proposed.
c. Explain any trends or patterns you noted in your data.
d. Show support or nonsupport of citing data.
e. Describe & explain measurement errors that could have affected you results.
f. Propose a new question that could be tested to more fully understand how variables affect reaction time.

APPENDIX P

GREAT FALLS PUBLIC SCHOOLS STEM EXPO RUBRIC

Great Falls Public Schools STEM EXPO Rubric				
Rubric Components	**Point Scale**			
	4 Strongly Agree	3 Agree	2 Somewhat Disagree	1 Disagree
BOOTH DESIGN AND ENHANCEMENT Props and visuals enhance the content and draw in the audience.				
COMMUNICATION Information is articulated and presented in a clear, logical and sequential way in both written and oral contexts.				
CREATIVITY AND INNOVATION A strong creative approach, processes and ideas are used in the design and implementation.				
ICT **(INCORMATION, COMMUNITCATIONS AND TECHNOLOGY)** The project integrates a variety and multiple forms of technology tools (in a safe and legal ways) to research, organize and evaluate the topic.				
CONTENT The topic is accurately researched and depicted and relates to STEM				
PROJECT IMPACT The project can/did impact classroom, school, and or the community and the project extends and connects to other experiences and real-world scenarios.				
RESEARCH/INQUIRY/PROBLEM SOLVING The project strongly demonstrates intentional planning, research, inquiry, problem solving, and critical thinking. Reasoning, interpretation of data and explanations of information and conclusions are effectively made based on evidence.				
STUDENT INTERVIEW The student(s) is very engaged and understand the project. The presentation is well organized and presented in a professional manner.				
	Total Score (28 possible)			
Additional Comments:				