USING DIFFERENTIATED PHYSICS HOMEWORK TO CREATE SELF-REGULATED LEARNERS

by

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of

Master of Science

in

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ABSTRACT

At the beginning of the year students were taught the Question Formulation Technique – a process that introduces the ideas of metacognition, convergent, and divergent thinking, as well as open and closed-ended questions. Then during each unit of study, students used the Question Formulation Technique to compile a list of questions. For homework, students examined their lists, and then identified five questions to prioritize for research in order to provide the greatest academic gain. To demonstrate academic growth, students created differentiated homework capable of teaching others in the form of their choice including songs, board games, and videos. This process was studied for its ability to improve students' attitudes about learning while at home, and to see if it encouraged self-regulated learning. The results of this study support the idea that students can use the Question Formulation Technique to differentiate physics homework. Many students improved their self-regulatory skills related to their physics education and a marginal improvement occurred in relation to student attitudes about learning while at home.

INTRODUCTION AND BACKGROUND

During my career in education, I have noted that students vary in proficiency across a wide range of physics related skills. A variance in skills can also be found in other courses. It is for this reason that educational research has increasingly investigated differentiated instruction for its ability to teach students at the appropriate cognitive level and through a variety of methods. In order to differentiate the process of learning within my classroom, I have developed student-learning communities in which students take on specific roles in order to help focus their efforts and to support the group as a whole. During class, students complete guided inquiries in which they answer questions of increasing difficulty by exhausting their resources and explaining their findings to peers. While I have not yet finished transforming my classroom into a fully differentiated and student-centered environment, I began to wonder if the uniform homework I usually assign could be improved through differentiation.

Differentiated homework assignments allow students to demonstrate their understanding of course learning goals through a variety of methods. For example, if a teacher assigns the task of explaining a rock-climbers state of translational equilibrium, a student could create a mathematical model, a diagram, or a graphical relationship in order to demonstrate their understanding of the situation. With differentiated homework, a student is free to explore the content in a way that most closely aligns with their interests and skills. I have seen differentiated homework promote content understanding, but I found myself wondering if each student requires additional practice with the same concepts. For those that have mastered a skill, can time be better spent elsewhere?

Through the use of formative assessments, I have found that students progress at varying rates during each unit: what was once novel may quickly become something that a student could synthesize. For a student that has reached the level of mastery with a certain skill, strengthening deficiencies in other areas can lead to the greatest academic gain. This train of thought led me to further differentiate homework by assigning students to work on their area of greatest need in addition to demonstrating their understanding in the way that they prefer.

Students at the high school level are expected to be able to demonstrate the eight practices of science and engineering, which includes the ability to ask questions and carry out investigations (NGSS Lead States, 2013). Differentiated homework can satisfy these requirements as students pursue answers to their own questions. While I have found that few students ask questions in class, perhaps the apparent apathy is not due to disinterest, but instead it is due to a lack of training. The Question Formulation Technique, a practice introduced in the book *Make Just One Change: Teach Students to Ask Their Own Questions*, may be an effective model for addressing this issue while differentiated homework empowers students to become life-long learners.

This led to the focus question for my classroom research project; *Does differentiated homework impact student perception of learning while at home, and can it promote self-regulated learning?* Data for this study was collected from the physics students (N=27) at Payson High School in the small mountain town of Payson, Arizona. Payson High School has 762 students, and 52% qualify for free and reduced lunch (C. Hatch, personal communication, January 13, 2016).

CONCEPTUAL FRAMEWORK

Despite efforts to create relevant, useful, and hands-on lessons, many teachers at every level struggle to keep students interested and engaged, especially when the student population varies in abilities. Differentiated instruction addresses this issue by teaching students at the appropriate cognitive level and through a variety of methods in order to provide options for students in terms of both content delivery and how they demonstrate their understanding. In order to effectively differentiate, student understanding must first be ascertained so that the appropriate concepts can be emphasized (*A Teacher's Guide*, 2007).

Differentiated instruction can be especially powerful when students answer their own questions (Powers, 2008). The Question Formulation Technique (QFT) engages students in self-regulated learning by teaching them how to ask their own questions and to keep track of their understanding through metacognition. This process starts by utilizing divergent thinking to generate questions related to the content. Convergent thinking then allows students to think about the questions they created, and whether specific questions would promote the understanding they seek. Ultimately, the QFT provides a jumping off point for student-created projects that demonstrate newfound knowledge (Rothstein & Santana, 2012). The QFT supports the Next Generation Science Standards science and engineering practices, which include asking questions, planning and carrying out investigations, and constructing explanations to communicate findings (NGSS Lead States, 2013).

When students experience learning strategies like videos, web simulations or online models, they can identify the method they find most beneficial, which motivates them to learn (Braund & Reiss, 2006; Corsi, 2010; Marlowe, 2012; Zupke, 2012). Self-regulated learning empowers students to pursue education by utilizing their inherent strengths to understand complex problems, while encouraging higher-order critical thinking skills (Corsi, 2010; Rogers & Swan, 2004). One study found that 96% of students participating in self-regulated learning had positive thoughts about the approach and its effect on their understanding and motivation to learn (Corsi, 2010).

Problem solving in the classroom is complemented by out-of-school learning on the Internet and in virtual worlds like video games where lessons are “exciting, challenging, and uplifting” (Braund & Reiss, 2006, p. 1374). Data indicates that 92% of teens access the Internet daily and 24% of teens report that they are almost always online (Lenhart, 2015). Teachers and students must learn to embrace technology, not only as a social networking tool, but also as a means of conveying high-quality, “rigorous, focused, and differentiated education” (Zupke, 2012, p. 6). The creator of the Flipped Classroom asserts that at home learning can be achieved through videos, web simulations, and other tools (Sams, 2011). The use of technology to aid learning outside of school advances the goals of science education, especially through an increased understanding of concepts (Braund & Reiss, 2006). Students can study real-world problems and use equipment in a virtual environment that school districts could never afford (Zupke, 2012; Braund & Reiss, 2006). One study found that students experienced a reduction in stress related to their science education when they came to class prepared with questions for discussion from their independent Internet studies (Marlowe, 2012).

Internet simulations can introduce students to entertaining visual representations of otherwise abstract ideas (Squire, Barnett, Grant & Higginbotham, 2004). Web simulations like PhET, from the University of Colorado at Boulder, enable students to adjust variables while promoting scientific inquiry and demonstrating concepts in qualitative and quantitative modalities (About PhET, 2015). Even regular video games facilitate experiential and inquiry-based learning, which promotes self-efficacy, goal setting and cooperative learning while providing near instantaneous feedback (Mayo, 2007). One study found that "Game mechanics enabled students to confront weaknesses in understandings, and physics representations became tools for understanding problems" (Squire et al., 2004, p. 513). A second study found dopamine levels increased in the brain while individuals played video games. Dopamine is vital to the exploration of new ideas and learning (Schlesinger, Johnson, & Panter, 2007).

Student understanding of science concepts can also be improved through educational videos. Many students are familiar with video technology, as data indicates that 24% of American teens have posted a video to a video-streaming website (Pew Research Center, 2012). In addition to student comfort and familiarity with this technology, videos promote differentiated learning because students can pause, rewind and re-watch a recorded lecture or demonstration as many times as they need. A quick "how to" video can also improve student self-efficacy and level of engagement (Hu & Driscoll, 2012; Linnenbrink & Pintrich, 2003; Rogers & Swan, 2004). Students have options when it comes to learning at home, and true self-regulated learners will strive to find materials that make learning educationally profitable (Rogers & Swan, 2004).

Student engagement in homework assignments can further be improved by creating open-ended projects that provide benefits outside of instructional outcomes (King, Newmann, & Carmichael, 2009; Rogers & Swan, 2004). Students feel motivated to participate in the learning process when work encourages them to demonstrate their knowledge in ways that match their talents and interests, thereby promoting student intrinsic motivation and increasing the sense of ownership that students have for the work that they complete. Students also find work that allows them to become responsible for informing, persuading, or helping others to be more applicable to real life. In order to address real-life problems, students must research topics, synthesize information not explicitly stated and generate a way to explain their findings (Deschryver, 2014; King et. al, 2009). In this way, students complete self-regulated learning and "The principles of science and engineering can be taught not only by playing games but by designing games" (Mayo, 2007, p. 34).

METHODOLOGY

During tenure at Payson High School, I noticed that few students completed their physics homework and that many of the submitted assignments had been done poorly. In order to see if this study could affect change, the intervention was launched at the beginning of the fall semester, and the experiences that students had prior to enrollment in this course served as the baseline for survey data (N=27). 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

(Appendix A). The purpose of this study was to determine if differentiated homework impacted student attitude, while promoting self-regulated learning.

During the first week of the semester, students were provided the rationale for differentiated homework as a means to help each individual with the specific content that they are struggling with the most. An Introduction to the Question Formulation Technique (QFT) was provided via tutorial (Appendix B). During this time, I explained that the QFT helps individuals to identify their area of highest need, which would ultimately become the focus of their homework assignment. Students were also introduced to the idea of becoming self-regulated learners, and they were provided a Hyperlink Handout to support their research at home (Appendix C).

As I had experimented with the QFT last year, I was able to display work from previous classes during the first week of the school year, and a discussion took place in order to clarify student questions and general expectations for the differentiated homework assignments. The main area of concern was establishing the focus area for differentiated homework. I informed the class that they should be keeping a record of the areas with which they feel uneasy, and as the class moved from one topic or activity to the next, students should be evaluating the depth to which they feel confident with their skills. The process of metacognition was stressed on a near daily basis, as thinking about one's depth of understanding is vital to becoming a self-regulated learner.

For each unit of study, students were only asked to complete one differentiated homework assignment. The differentiated homework entailed the completion of the QFT Handout in order to identify the subject matter that should be emphasized for homework, and the creation of a project capable of teaching others (Appendix D). In order to demonstrate their newfound understanding of the content, students submitted projects that taught the material through games, stories, songs, etc. The homework assignments were due the week preceding the unit exams.

Prior to introducing the QFT and differentiated homework, data was collected via the Science Motivation Questionnaire II (Appendix E). This Likert style survey contains 25 statements related to the concepts of motivation and interest in learning physics. During this survey, students were asked if they find learning physics to be interesting, or if they are interested in physics discoveries. Scores for each question on this survey range from never (0) to always (4). At the conclusion of this study, in March of the same school year, students revisited the Science Motivation Questionnaire II. The pre and post-treatment data from this Likert style survey was analyzed visually by using diverging stacked bar charts.

A second Likert style survey, the Colorado Learning Attitudes about Science Survey, was conducted prior to the implementation of this study (Appendix F). This instrument contains over 40 statements related to students' attitudes and beliefs about learning physics. For each statement, students were asked to rate their response from strongly disagree (1) to strongly agree (5). During this survey, students were asked if they think about physics in their everyday life, and if reading the text is an effective method for learning. Another question asked about a student's ability to learn if the teacher does a poor job explaining the content during class. Following the end of this study, students retook the Colorado Learning Attitudes about Science Survey. The pre and post-treatment data from this survey was analyzed visually by using diverging stacked bar charts.

In addition to the Likert data, 22.22% of my students volunteered to complete the Student Attitude and Interest in Homework Interview (Appendix G). The goal of this interview was to acquire an open-ended response in regards to student attitude, effort, and motivation as it relates to learning outside of the school day. Interviews were conducted prior to and following the conclusion of this study. Questions were analyzed for themes to support numerical findings. The table below can be used to see how data for this study has been triangulated.

Table 1
Data Triangulation Matrix

Research Questions	*Data Source*			
	1	2	3	4
1. How will differentiated homework impact students' mindset about learning?	Science Motivation Questionnaire II	Colorado Learning Attitudes about Science Survey	Student Attitude and Interest in Homework Interview	Teacher notes and observations
2. Does differentiated homework promote self-regulated learning?	Science Motivation Questionnaire II	Colorado Learning Attitudes about Science Survey	Student Attitude and Interest in Homework Interview	Teacher notes and observations

DATA AND ANALYSIS

Submission results for differentiated homework assignments indicate that students created their own questions, conducted independent research, and then communicated their findings, on average, 60% of the time (Figure 1). Differentiated homework was submitted at varying rates throughout the study, with as many as 74.07% of students submitting homework for 2-Dimensional Kinematics, and just 44.44% of homework assignments being submitted during the unit on Newton's Laws of Motion (*N*=27). The median submission rate for was 59.26% and the mode was 55.55%. After the study, one student identified the number one factor impacting whether or not he completed a homework assignment as, "Motivation. It's hard to work on the stuff that I'm not good at, and for most of my classes I can skate by with easy 'A's' and 'B's'. This homework was really challenging because you really have to know what you're talking about."

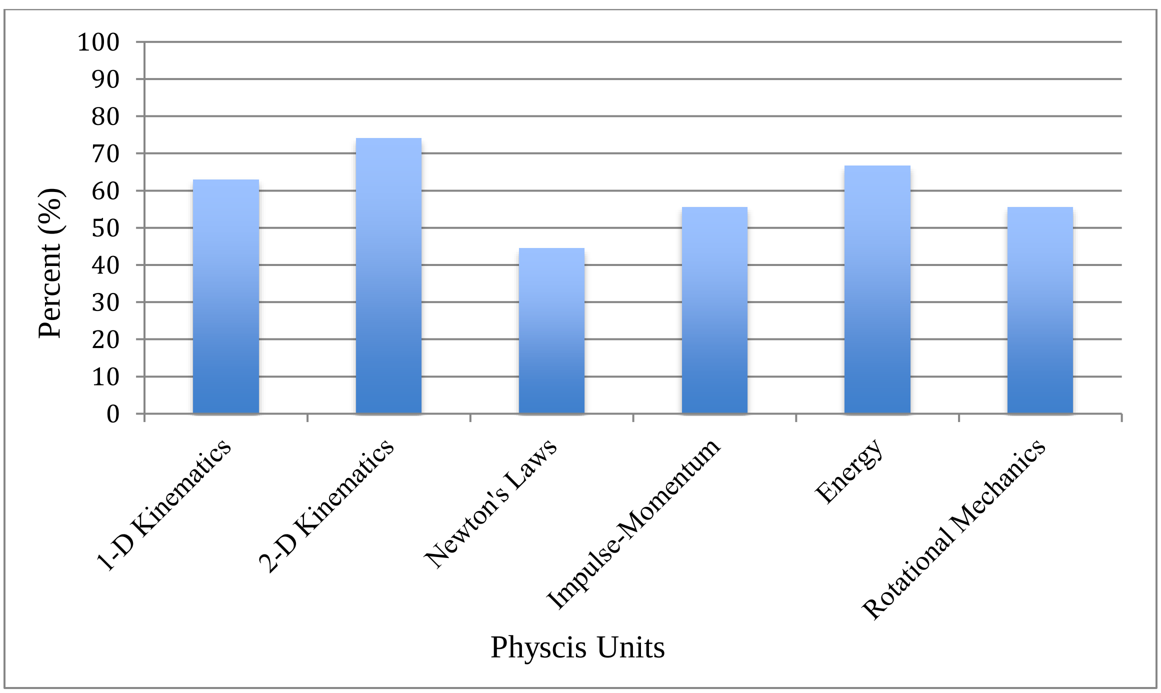

Figure 1. Homework submission rates by unit, (*N*=27). *Note.* The data sets are shown in the order in which the units were completed.

When asked of their opinion during the Colorado Learning Attitudes about Science Survey, a noticeable shift occurred when comparing the pre and post-treatment data. Following the implementation of this study, the number of students who felt that they could solve a problem on their own, even after an initial struggle, increased by 11.11% (Figure 2). In addition, there was a 14.81% increase in the number of students that *strongly agreed* that nearly everyone is capable of understanding physics. After completing differentiated homework, there was a 3.71% increase in the number of students that *strongly agreed* that they enjoy solving physics problems. When asked about his thoughts or emotions as they relate to differentiated science homework, one student said, “I’m excited to learn about the stuff that I need help with, and it was cool that I could turn my homework into a game or an essay.”

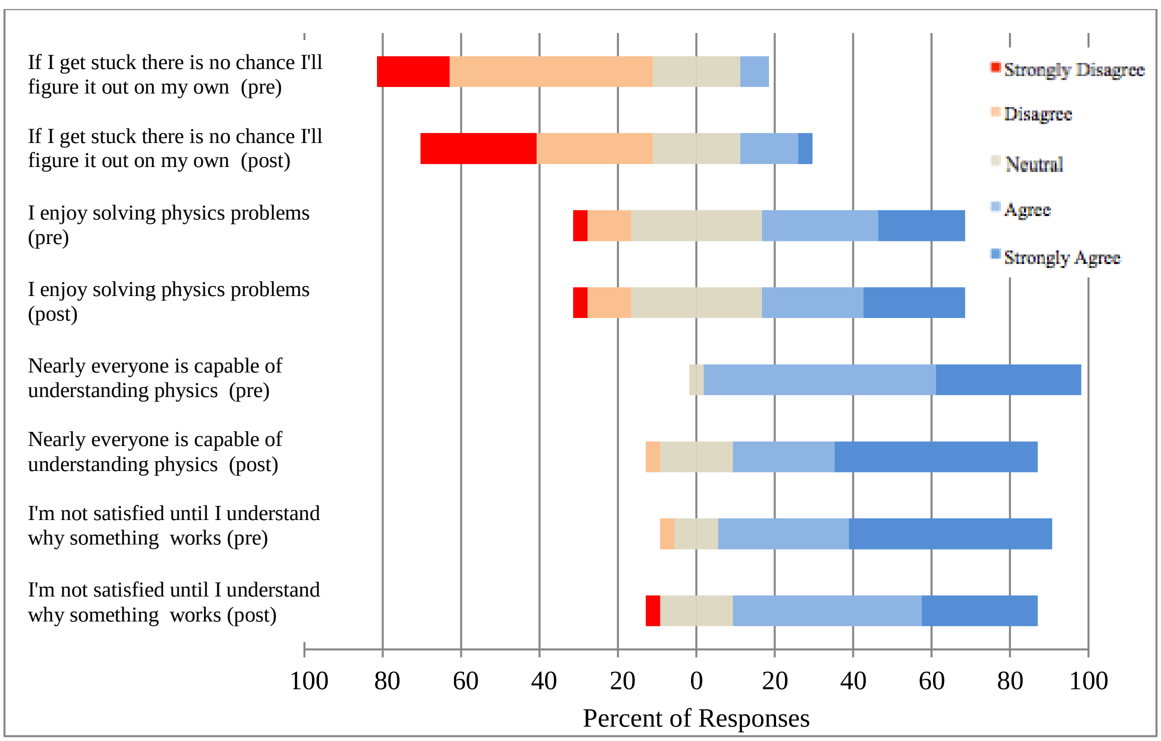

Figure 2. Pre and post-treatment responses from the Colorado Learning Attitudes about Science Survey, (*N*=27). *Note*. For each set of data shown above, the *neutral* response was centered on zero and *strongly disagree* and *disagree* are shown to the left of zero.

Other results from the Colorado Learning Attitudes about Science Survey show a 14.82% increase in the number of students that *strongly agree* that discussing physics with friends helped their understanding, and a 7.41% increase in negative responses to the same question (Figure 3). Once becoming stuck on a problem the number of students that found another way to solve increased by 7.41%. A 22.22% decrease in the number of students that related information to previous knowledge was also seen following the implementation of differentiated homework. When asked what problem solving strategies can be used to further your understanding while at home, one student responded, “First, I look at my notes. If that doesn’t help I try to find something from the hyperlinks that explain it: like a video. Sometimes I’ll call friends, or look at similar problems. For most questions, once I can picture the problem I can usually figure it out.”

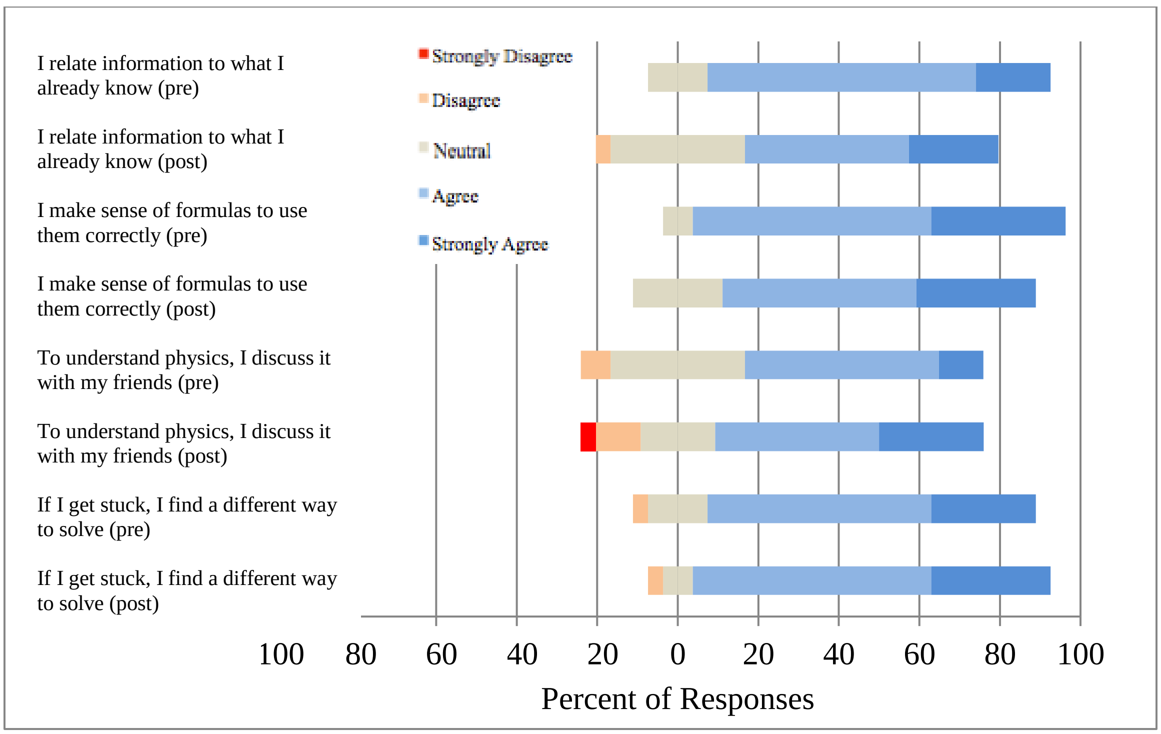

Figure 3. Pre and post-treatment responses from the Colorado Learning Attitudes about Science Survey #2, (N=27). *Note*. For each set of data shown above, the *neutral* response was centered on zero and *strongly disagree* and *disagree* are shown to the left of zero.

Results from the Science Motivation Questionnaire II show an 11.11% increase in the number of students that *often* or *always* enjoy learning physics (Figure 4). An 11.11% growth was also seen amongst *often* or *always* responses that learning physics is interesting. Meanwhile, there was a 14.82% increase in the number of students that said they *never* or *rarely* put enough effort into learning physics. Similarly, when asked about using strategies to learn physics, the number of students that responded *never* or *rarely* increased by 7.41%. Following the implementation of this study, one student said, "I like physics, but at the end of the day, I'm just so tired from school and sports that I have no interest in working on anything else." Another student said, "Physics is fun, but I get nervous doing homework. I feel like I could have done better on my homework."

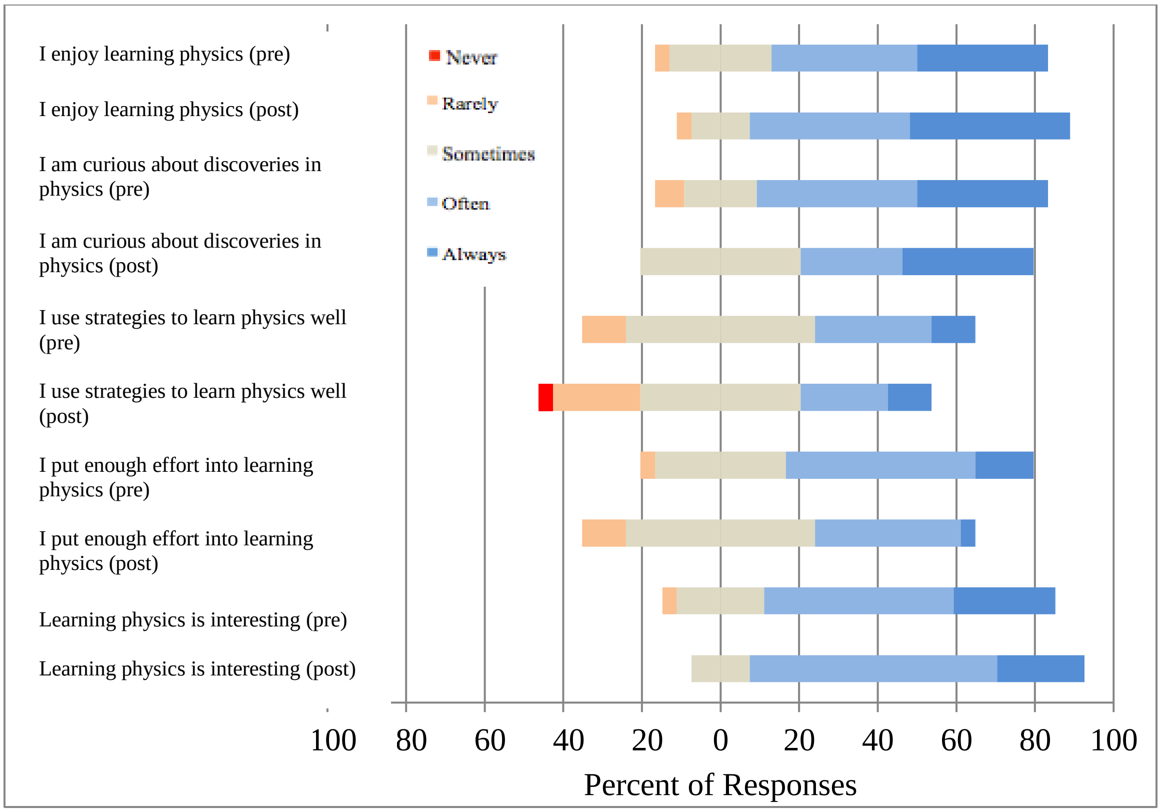

Figure 4. Pre and post-treatment responses from the Science Motivation Questionnaire II, (*N*=27). *Note*. For each set of data shown above, the response of *sometimes* was centered on zero and *rarely* and *never* is shown to the left of zero.

INTERPRETATION AND CONCLUSION

Due to the nature of this physics homework, successful completion required students to ask questions, plan and carryout investigations, and construct a project to communicate their findings. In short, differentiated physics homework utilized many of the eight practices of science and engineering. While the average rate of submission was nearly 60%, some of these projects were done haphazardly and a few examples never progressed beyond asking questions, the first of the eight practices. For 29.62% of my students, they demonstrated the ability to complete their homework in its entirety for each unit of study. Based on this subset of physics students, the data suggests that students are capable of becoming self-regulated learners. Survey results seem to indicate that this intervention was not entirely effective; meanwhile student interviews revealed some positive changes as related to their mindset about learning.

Following introduction to the Question Formulation Technique, I noticed a new phenomenon. For the first time in my teaching career, I heard my students alter their questions in class, from open-ended to closed-ended or vice-versa, in order to create questions that more appropriately addressed their needs. At times, a student would start to ask a question, but then stop as they realized that the concept in question could be recorded on the QFT Handout and answered via independent research. It seemed obvious to me that some students were using metacognition to evaluate the depth of their understanding and whether or not they needed additional emphasis in that area. For students that completed differentiated homework, the questions recorded on the QFT Handout became their learning goals.

In order for students to attain their self-determined learning goals, they completed independent research and used learning strategies. The specific learning goals varied dramatically, and in any given unit there was a minimum of eight different focus areas. When asked about available tools or resources that exist at home prior to the implementation of this study, one student said, "I have the Internet." When asked how the student would use the Internet, he said, "I'll look up the concept." Following the conclusion of this study, this student responded to the same question by saying, "I usually look at my inquiry first: that helps a lot. I also like to use the (PhET) online labs, because it really helps to see an event and the graph at the same time. I just started using the projects you posted online from last year's students, those help too." At the end of this study I asked students to identify problem-solving strategies that they used while at home. One student responded, "I like to start by thinking about the question, and then I draw a picture. Once I label everything on the drawing I can usually figure out which equation to use." Another student responded by saying, "I like to start by thinking about the units required for the answer. If I know the answer is a velocity, and it's measured in m/s, then I find a formula that works for the situation and gives me the units I want."

The way in which students wanted to demonstrate their understanding was diverse. The most common project style was that of an essay, but other projects included board games, songs, videos, PowerPoint presentations and laboratory experiences. As one student reflected on his ability to complete science homework he said, "I wish that I spent more time on my projects, I though it would be cool to make a game or something, but for each homework we had so much time, so, I kept putting it off. I kept relying on essays, because I knew that I could summarize the concepts by using my inquiries and notes." This student's response brings up one possible reason for low submission rates. Given the length of time to complete these homework assignments, a little more than two weeks, students may not have felt the same sense of urgency that they do for work that is to be submitted the following day. A second factor that could have driven down the submission rates, especially amongst my low performing students, was that they were asked to work on something that was difficult. In his response, this student also alluded to a common issue with the homework that students submitted. They did not focus on the material that was difficult, but rather on material that they thought was relatively easy so that they could get the work done quickly.

Data from the Colorado Learning Attitudes about Science Survey and the Science Motivation Questionnaire II indicate that most students enjoyed learning about physics, and that they found the topic to be interesting. The data from these surveys can also be used to show that students acquired an awareness of the level to which they understand the course materials and the quality of the effort that they put forth to do so. Following implementation of this study there was an increase in the number of students that indicated that they don't put enough effort into learning physics, and an increase in respondents that said they *never or rarely* use learning strategies to understand physics. While this is not a positive thing for their attainment of the course materials, it does show that students are reflecting on their choices. When asked if differentiated homework encouraged self-regulated learning, one student responded, "Yes, it's better than doing the regular homework, where everyone has the same assignment and you can just breeze through it. It gets you thinking about what you are struggling with so that you can make it one of your strengths. It gives you confidence because you know that topic for sure." While there was an increase in the number of students that *strongly agreed* that nearly everyone is capable of understanding physics, the number of students that had selected *neutral* or *disagree* also increased. At the conclusion of this study one student said, "Sometimes its hard to learn the materials on your own. Some homework assignments were extensions of classwork, but others were based on some of the connections you spoke of with AP Physics. For those topics that we never really covered in class, I had a hard time."

VALUE

Albert Einstein once said, "Teaching should be such that what is offered is perceived as a valuable gift and not as a hard duty." After completing this study, I now firmly believe that this quote epitomizes my role as an educator. In my efforts to teach students physics, I have also been trying to impart one of the greatest gifts of all, intellectual curiosity. While I understand that the majority of my students will never take another physics class, everyone will encounter another struggle, and most everyone will strive for greatness in some avenue. In order to overcome these challenges, we must understand what is going on and how to improve the situation. In this way, self-regulated learning will be integral in our lives. Differentiated homework may not have been the best way to teach this lesson, but for those that tackled their weaknesses in physics this year, they have gained confidence with their abilities and challenges became achievements. Now as I reflect on this study, I have noticed how my thoughts have developed as they relate to teaching about self-regulated learning.

My ambition to teach others about intellectual curiosity was a true challenge. I wanted to instill in my students the ability to go above and beyond and to work towards improving their understanding not because of the demands of a teacher but because they know that it will help them to be successful. However, the majority of our students at Payson High School come from a poor socioeconomic background, and they have experienced little emphasis on excelling in academics. Our guidance department has even referred to educational rigor as a hardship. These issues have made this process of teaching self-regulated learning that much more challenging, as I am asking students to go beyond the low lying expectations that they are accustomed to and to address their self appointed shortcomings. Through this trial by fire, I grew frustrated as I realized that some of my students were choosing apathy over education.

Some of my students never submitted differentiated homework, and for a select few, it is unlikely that they would have submitted a traditional homework assignment. For most of my top-achieving students, however, this homework is something that they seem to have been waiting for. They worked hard, they improved the skills that they were weak at, they used their talents to design creative ways to teach the content, and they grew as self-regulated learners. It was during these moments that I could truly see the validity in this study. This process was not without its struggles though, even for my top students. As some of the higher achieving students noticed others completing projects on topics that they already felt masterful in, like definitions, a certain amount of apathy seemed to set in. I even heard one student exclaim to his lab partner that it wasn't fair that he did his project on a harder topic but had a worse grade. I tried to explain to the student that his errors in the project are what led to a lower grade, but that didn't seem to matter. It has become apparent to me that high school students will continue to compare themselves and their knowledge to others and they will just as readily rise to the level of their competition or sink down to it.

I believe this study has some value for teachers within any classroom, and with refinement, differentiated homework may even offer a method towards consistent attainment of the science and engineering practices in the Next Generation Science Standards. The Questions Formulation Technique is a great thing to teach students, as it can empower them to find answers to their questions. Furthermore, this technique can be can be used in a variety of ways, like at the beginning of a unit for the purpose of collecting data on prior knowledge and interest, or to create tier two intervention groups based on similar question types, and it can be used for creating project ideas in which students can pair their talents and interests with the content. The idea of differentiated homework should be further explored for its capacity to expand science education by willful participation from home. Possible steps towards improving this process include deliberately outlining all eight of the science and engineering practices with students and providing a timeline for the completion of those objectives.

Following implementation of this study, I am left wondering where this concept would be most effective. Interestingly, I found that students with an "A" in physics completed their homework 100% of the time, those with a "B" completed it less than

50% of the time with some students only submitting one or two assignments. Perhaps with the possible improvements identified above, this form of homework could be used at a school that places a large emphasis on academic performance. Differentiated homework may be best used for adult students that understand that a tremendous amount of growth occurs when strengthening our shortcomings.

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APPENDICES

APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

MONTANA STATE UNIVERSITY

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MEMORANDUM

TO: Andrew Fiala and John Graves

FROM: Mark Quinn *Mark Quinn CJ*

DATE: August 14, 2015

RE: *"Differentiated Science Homework Creates Self-Regulated Learners" [AF081415-EX]*

The above research, described in your submission of **August 14, 2015**, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

_X_ (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

_X_ (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

APPENDIX B

INTRODUCTION TO THE QUESTION FORMULATION TECHNIQUE

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Question Focus

$\Delta X = v_o(t) + ½ at^2$

+

Questions: Divergent Thinking

- Ask as many questions as you can, a minimum of 10, that you have that are related to our Question Focus: $\Delta X = v_o (t) + ½ at^2$
- Do not stop to discuss, judge, or answer any of the questions.
- Write down every question exactly the way that the question comes to mind.
- Change any statements into questions.

+

Questions: Convergent Thinking

- Evaluate the questions that you created by determining if each question is "closed" or "open-ended."
  - Closed-ended questions can be answered with a single word, like yes or no.
  - Open-ended questions require an explanation.

+

Questions: Convergent & Metacognitive Thinking

- Some common key words for closed-ended questions:
  - Is?
  - Do?
  - Can?
- Some common key words for open-ended questions:
  - Why?
  - How?

+

Questions: Metacognitive Thinking

- Metacognition is the awareness and understanding of one's own thought processes.
- After you have categorized all of the questions as closed or open-ended, identify and discuss the advantages and disadvantages of those two different question styles with those sitting near you.

+

Questions: Convergent & Metacognitive Thinking

- Analyze the list of closed-ended questions that you have come up with, and identify (at least) one question that would be better if it were open-ended. Then change that question so that an explanation is required. Alter your original question on the handout.
- Analyze the list of open-ended questions that you have come up with, and identify one question that would be better if it were closed-ended. Then change that question so that an answer would take the form of a simple, one-word, answer. Alter the original question.

+
Questions: Convergent & Metacognitive Thinking

- Some common key words for closed-ended questions:
  - Is?
  - Do?
  - Can?
- Some common key words for open-ended questions:
  - Why?
  - How?

+
Questions: Metacognitive Thinking

- Now that you have developed a bunch of questions, you can evaluate that list and prioritize.
- Identify the top 5 questions, by numbering from 1-5, that you have come up with on the handout.
- You should be trying to identify WHY certain questions should be prioritized before others.
- At this time questions can be edited and combined to concentrate on addressing the Question Focus.

+
Questions: Metacognitive Thinking

- Now you have a series of questions, listed in a logical order, which you can use in order to conduct research and gain content understanding.
- As metacognition deals with self-awareness of growth and understanding, you should be keeping track of your progress while answering your research questions. If a website/video/book is not helping, move on to something else.

+
Next Steps…

- The next step in this process, after research, is to produce:
  - a study guide…
  - a review game…
  - a video explanation…
  - a model…
  - an informative handout…
  - how would you like to demonstrate your understanding?

APPENDIX C

HYPERLINK HANDOUT

Hyperlink Handout
Readings, Simulations & Animations

KINEMATICS:

One-Dimensional Kinematics

Readings:

This link provides you with specific components of 1-dimensional kinematics. Take your time to walk through each of the links to further understand the relationship presented in this unit.
http://www.physicsclassroom.com/class/1DKin/

Select this link for a 1-dimensional kinematics review after the aforementioned reading.
http://www.physicsclassroom.com/reviews/1Dkin/1Dkinrev.cfm

Simulations:

Download or click "run now" in order to use this online graphing activity. Select the tab, "charts" at the top of the program for useful data analysis. http://phet.colorado.edu/en/simulation/moving-man

Animations:

The following link provides a small video series explaining the relationship between displacement, velocity and acceleration.
http://www.animations.physics.unsw.edu.au/mechanics/chapter1_constantacceleration.html

The link provided below shows the first and second derivatives of a displacement vs. time graph.
http://faraday.physics.utoronto.ca/PVB/Harrison/Flash/ClassMechanics/ConstantAccel/ConstantAccel.html

Two-Dimensional Kinematics

Readings:

Click this link and head to lesson 2, which deals with projectile motion. Take your time to read and walk through each of the links to understand the effects of gravity and the relationship between vertical and horizontal motion. http://www.physicsclassroom.com/class/vectors/

Select this link for a review of vectors and projectile motion after the aforementioned reading.
http://www.physicsclassroom.com/reviews/vectors/vectorsrev.cfm

Simulations:

Download or click "run now" in order to use this online projectile range, height and time finder.
http://phet.colorado.edu/en/simulation/projectile-motion

Animations:

The link below allows the user to manipulate the angle and starting displacement of a projectile.
http://www.upscale.utoronto.ca/GeneralInterest/Harrison/Flash/ClassMechanics/Projectile/Projectile.html

The following link provides a short video series explaining one and two-dimensional motion.
http://www.animations.physics.unsw.edu.au/mechanics/chapter2_projectiles.html

DYNAMICS:

Force, Friction and Statics (Newton's 1st and 2nd Laws of Motion)

Readings:
This link provides you with specific components of Newtonian Mechanics aka Dynamics. Take your time to walk through each of the links. http://www.physicsclassroom.com/class/newtlaws/

Select this link for a review of Newton's 1st and 2nd LoM after the aforementioned reading. http://www.physicsclassroom.com/reviews/newtlaws/newtlawsrev.cfm

Simulations:
Download or click "run now" in order to use this online Force, acceleration, displacement and velocity activity. Select the tab, "Force Graphs" at the top of the program for useful data analysis. http://phet.colorado.edu/en/simulation/forces-and-motion

Animations:
The animation below shows the effects of force on objects of varying mass. http://zonalandeducation.com/mstm/physics/mechanics/forces/newton/newtonLaw2.html

Action Reaction (Newton's 3rd Law of Motion)

Readings:
Click this link and head to lesson 3, which deals with translational equilibrium. Take your time to read the explanation and sample problems. In addition, work through the practice problems. http://www.physicsclassroom.com/class/vectors/

Simulations:
The link found below introduces many examples of Newton's LoM including free-body diagrams. http://www.physicsclassroom.com/Physics-Interactives/Newtons-Laws

Animations:
A short video series explaining Newton's 3 Laws of Motion can be found below. http://www.animations.physics.unsw.edu.au/mechanics/chapter5_Newton.html

Momentum

Readings:
Select this link to understand momentum, the impulse momentum theorem and its connection to Newton's Laws of Motion. http://www.physicsclassroom.com/class/momentum/

Select this link for a review of momentum and collisions after the aforementioned reading. http://www.physicsclassroom.com/reviews/momentum/momrev.cfm

Simulations:
Download or click "run now" in order to use this online momentum and velocity activity. Select the box to the lower left that says "more data" to show data for calculations. http://phet.colorado.edu/sims/collision-lab/collision-lab_en.html

Animations:
Select the link below in order to investigate elastic and inelastic collisions. http://faraday.physics.utoronto.ca/PVB/Harrison/Flash/ClassMechanics/AirTrack/AirTrack.html

APPENDIX D

QFT HANDOUT

QUESTION FOCUS:

Create at least 10 questions related to the material that you need the most help with.

_____1. ____

____

_____2. ____

____

_____3. ____

____

_____4. ____

____

_____5. ____

____

_____6. ____

____

_____7. ____

____

_____8. ____

____

_____9. ____

____

_____10. ____

____

Evaluate your questions in order to determine if the answer would be open or closed-ended. Place an "O" in the space next to open-ended questions and a "C" in the space next to closed-ended questions. Then, identify the top-5 questions, by numbering them 1-5, based on the questions' ability to address the Question Focus. You may combine and edit your questions at this time. Record your finalized questions, in the correct order, on the back of this paper.

My Top-5 Questions

1. ____

____

____

____

2. ____

____

____

____

3. ____

____

____

____

4. ____

____

____

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5. ____

____

____

____

APPENDIX E

SCIENCE MOTIVATION QUESTIONNAIRE II

SCIENCE MOTIVATION QUESTIONNAIRE II (SMQ-II) © 2011

SHAWN M. GLYNN, UNIVERSITY OF GEORGIA, USA

DISCLAIMER: Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

In order to better understand what you think and how you feel about your physics course, please respond to each of the following statements from the perspective of "When I am in a physics course..."

Statements	**Never (0)**	**Rarely (1)**	**Sometimes (2)**	**Often (3)**	**Always (4)**
1. The physics I learn is relevant to my life.					
2. I like to do better than other students on physics tests.					
3. Learning physics is interesting.					
4. Getting a good physics grade is important to me.					
5. I put enough effort into learning physics.					
6. I use strategies to learn physics well.					
7. Learning physics will help me get a good job.					
8. It is important that I get an "A" in physics.					
9. I am confident I will do well on physics tests.					
10. Knowing physics will give me a career advantage.					
11. I spend a lot of time learning physics.					
12. Learning physics makes my life more meaningful.					
13. Understanding physics will benefit me in my career.					
14. I am confident I will do well on physics labs and projects.					
15. I believe I can master physics knowledge and skills.					
16. I prepare well for physics tests and labs.					
17. I am curious about discoveries in physics.					
18. I believe I can earn a grade of "A" in physics.					
19. I enjoy learning physics.					
20. I think about the grade I will get in physics.					
21. I am sure I can understand physics.					
22. I study hard to learn physics.					
23. My career will involve physics.					
24. Scoring high on physics tests and labs matters to me.					
25. I will use physics problem-solving skills in my career.					

APPENDIX F

COLORADO LEARNING ATTITUDES ABOUT SCIENCE SURVEY

DISCLAIMER: Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

CLASS

(Colorado Learning Attitudes about Science Survey)

Name: ______________________________ **Last 6 digits of your Student ID #:** _______

Introduction

Here are a number of statements that may or may not describe your beliefs about learning physics. You are asked to rate each statement by circling a number between 1 and 5 where the numbers mean the following:

1. Strongly Disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly Agree

Choose one of the above five choices that best expresses your feeling about the statement. If you don't understand a statement, leave it blank. If you understand, but have no strong opinion, choose 3.

Survey

1. A significant problem in learning physics is being able to memorize all the information I need to know.

Strongly Disagree	1 2 3 4 5	Strongly Agree

2. When I am solving a physics problem, I try to decide what would be a reasonable value for the answer.

Strongly Disagree	1 2 3 4 5	Strongly Agree

3. I think about the physics I experience in everyday life.

Strongly Disagree	1 2 3 4 5	Strongly Agree

4. It is useful for me to do lots and lots of problems when learning physics.

Strongly Disagree	1 2 3 4 5	Strongly Agree

5. After I study a topic in physics and feel that I understand it, I have difficulty solving problems on the same topic.

Strongly Disagree	1 2 3 4 5	Strongly Agree

CLASS is a five-page survey. One page of the survey has been included at this time.

APPENDIX G

STUDENT ATTITUDE AND INTEREST IN HOMEWORK INTERVIEW

Student Attitudes and Interest in Homework

DISCLAIMER: Participation in this research is voluntary and participation or non-participation will not affect a student's grades or class standing in any way.

1. What thoughts or emotions come to mind when you are assigned science homework?

2. When completing an assignment at home, what tools or resources do you have available for help?

3. If you do not understand a concept, what problem solving strategies can you use to further your understanding while at home?

4. Describe the work habits that you have developed in regards to completing science homework.

5. Describe your attitude as it relates to completing science homework.

6. How would you describe your ability to complete science homework?

7. How would you describe your interest in completing science homework?

8. What is the number one factor impacting whether or not you complete a homework assignment?

9. What might make you more interested in completing homework?

*10. Do you think differentiated homework encouraged you to become a self-regulated learner? In other words: did you start to set goals, use learning strategies, and reflect on outcomes?

11. Is there anything else that you want me to know?

*This question is only read after the completion of the study.