

USING MENUS AS A DIFFERENTIATION TECHNIQUE IN SMALL MULTILEVEL  
LIFE SCIENCE AND PHYSICAL SCIENCE CLASSROOMS

by

Diane Marie Martin

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## TABLE OF CONTENTS

1. INTRODUCTION AND BACKGROUND .....	1
2. CONCEPTUAL FRAMEWORK .....	2
3. METHODOLOGY .....	7
4. DATA AND ANALYSIS .....	10
5. INTERPRETATION AND CONCLUSION .....	23
6. VALUE .....	25
REFERENCES CITED.....	28
APPENDICES .....	31
APPENDIX A Unit Menu Template and Treatment Menus .....	32
APPENDIX B Student Attitude Survey .....	40
APPENDIX C Student Pre- and Post-Unit Interview .....	43
APPENDIX D Teacher Log Book Template.....	45
APPENDIX E Pre- and Post-Unit Assessments .....	47
APPENDIX F IRB Exemption Form.....	73

LIST OF TABLES

1. Data Collection Techniques.....	9
2. Preliminary Attitude Survey—Physical Science Class.....	13
3. Preliminary Attitude Survey—Life Science Class .....	14

LIST OF FIGURES

1. Normalized Gains of Physical Science Students’ Mastery of Content Standards in Each Unit .....	10
2. Normalized Gains of Life Science Students’ Mastery of Content Standards in Each Unit .....	11
3. Physical Science Student Average Scores on Unit Activities in Each Unit .....	12
4. Life Science Student Average Scores on Unit Activities in Each Unit .....	13
5. Student Answers to Likert-style Survey Questions—Physical Science Class.....	16
6. Student Answers to Likert-style Survey Questions—Life Science Class .....	16

## ABSTRACT

Differentiating instruction for classes that include a diverse group of learners can be challenging. In this research project, the use of menus as a differentiation method was studied with two classes at a small, rural school. The first class studied was a 7<sup>th</sup>-8<sup>th</sup> grade life science class of 11 students, the second was a 9<sup>th</sup>-grade physical science class of seven students. Each class was taught four separate units. In two of the units, students were given a list-style menu of activities from which they selected a certain number of their choice to demonstrate their mastery of the unit objectives. The other two were taught using a more traditional mixture of mini-lectures, labs, and written activities in which the entire class received the same assignment. Student mastery of unit objectives, student attitudes towards science in general and their class in particular, and the effects of this teaching method on the classroom teacher were investigated using a range of data collection methods including pre- and post-unit assessments, student written surveys, student oral interviews, and a teacher journal. Although no significant overall trends in student content mastery were observed during this research, the performances of some individual students in both classes were affected negatively by this technique, while others showed a slight improvement in mastery during the treatment units. The majority of students liked having the ability to choose activities and be responsible for their own learning. The researcher intends to use a modified form of the menu-style units in the future, perhaps with a more limited scope and shorter time frame.

## INTRODUCTION AND BACKGROUND

The researcher teaches all of the fifth through twelfth grade science classes at Lima School, a small rural school in southwestern Montana. Most of the classes are small (ranging from two to fifteen students) and include students with a range of grade levels, ability levels, and interests. Lima School currently has 11 junior high (7<sup>th</sup>-8<sup>th</sup> grade) students and 23 high school students. Eighteen percent of the junior high students and nine percent of the high school students are Hispanic, and nine percent of the high school students are Native American. The remainder (82% of the students) are Caucasian. Thirty-six percent of the junior high students and 65% of the high school students receive free or reduced-price lunch. Seventy three percent of the junior high students have at least one parent with some post-high school education while only 48% of the high school students do (B. Rayburn, personal communication, March 29, 2017).

Differentiating instruction for these students can be challenging and this research project was intended to test the efficiency and effectiveness of one differentiation method; that is, using a menu-driven unit design. Menus can be used at any academic level to increase student choice and independence in their learning. A menu gives a variety of learning activity options that address a particular teaching objective. Students can then choose which activities from the menu they will complete and in what order they will complete them. For this project, list-style menus were used to give students control over which activities they completed to meet their unit objectives, while ensuring that they used at least some higher-order thinking skills and had the chance to use different learning styles. Although this research was conducted in a small-school setting,

the need to differentiate instruction is a universal one and the themes explored here could be useful to educators in many different settings when designing teaching methods for their students.

The main research question for this project was, “How effective is a menu-driven learning method as measured by students’ mastery of unit standards?” An additional two research subquestions were also addressed, namely:

- “What are the effects of a menu-driven learning method on student attitudes towards their science class and science in general?”
- “How does a menu-driven learning method impact the classroom teacher?”

During the research process, the researcher had the assistance of three people. Brian Rayburn, the principal and superintendent of the school district, read the research proposal and methodology plan and gave constructive criticism. Anna Arndt, a 5<sup>th</sup> and 6<sup>th</sup> grade and special education teacher in the building also read and commented on the writing, as well as providing helpful suggestions for ways to design the research project. Thirdly, the researcher’s husband, Ryan Martin, who is a wildlife biologist and range manager, offered input about ways to frame questions and to design data collection instruments. In addition, a science reader, Robyn Klein, helped with the formatting and structure of the final paper.

## CONCEPTUAL FRAMEWORK

The ultimate goal of this classroom research project was to find an effective and workable way to differentiate instruction in small classes with a wide range of ability levels. There are many differentiation techniques available that have been shown to



improve student performance, including modified discussions, student goal-setting, peer tutoring, compacting curriculum, independent projects, tiered assignments, experiments, and learning contracts (Hootstein, 1998). In one study, for example, the majority of students in a high-school earth and space science course were found to prefer a curriculum that included differentiated alternative assessments to one with traditional assignments and assessments (Waters, Smeaton, and Burns, 2004).

This classroom research project is based on a constructivist view of learning that assumes that the student must put knowledge together rather than have it delivered by the teacher. There are several different definitions of constructivism, but a comprehensive view of it includes the idea that spontaneous concepts can be discovered by an individual but scientific concepts (constructed over a long period of time by society) must be passed on from adults to children, who then must add these concepts to their own knowledge. A teacher's role is to facilitate the construction of new knowledge by introducing the necessary concepts to students, providing multiple opportunities for students to apply new concepts to different situations or problems, and assisting students to learn the processes of logical thought and abstract thinking necessary to integrate new knowledge with prior knowledge (Bächtold, 2013).

Classrooms which contain a diverse student body, whether due to academic background, ability, socioeconomic class, or ethnicity, require teachers to intentionally address this diversity in their teaching methods in order to promote student success (Tomlinson, Brighton, Hertberg, Callahan, Moon, Brimijoin, Conover and Reynolds, 2003). These methods should address student readiness, interests, and learning

profiles, and they should be proactive, include the use of small teaching-learning groups, vary the use of materials, use variable pacing, and be knowledge- and learner-centered.

The key features of successful differentiation are a focused, high-quality curriculum, ongoing formative assessment, a positive community of learners, flexible instructional arrangements, and respectful tasks for students (Maeng and Bell, 2015). Watanabe, Nunes, Mebane, Scalise, and Claesgens (2007) found in a two-year research-based case study that, in addition to these characteristics, successful differentiation in mixed-ability high school science classrooms depended on four specific beliefs and practices. These were the teacher's belief in a developmental conception of ability and intelligence, the use of inquiry-based activities incorporating real-world contexts, a focus on teaching students study skills, and a strong sense of community and individual responsibility for student learning.

Some quantitative research studies have been done that support the effectiveness of these types of differentiation techniques. In a study of 100 graduate-level students, it was found that learning contracts, which allowed students to select their learning activities from a menu, led to a significant improvement in academic performance and an increase in students sense of personal responsibility and decision-making power (Lemieux, 2001). In another study of 213 middle school students, collaborative hands-on peer-mediated activities were shown to significantly improve student performance on end-of-unit tests and annual standardized tests and that students enjoyed the activities more than traditionally taught units (Mastropieri, Scruggs, Norland, Berkeley, McDuffie, Tornquist, and Connors, 2006).

These articles provide a philosophical background to support the course design and teaching methods used in this classroom research project and a framework to help design successful differentiated instruction in a diverse classroom. Providing a menu of activities for students to select from should allow for the application of new concepts in a variety of ways to address different academic backgrounds, ability levels, and learning styles.

Several articles have provided ideas for data collection and analysis for this classroom research project. For example, this project required the administration of student interest surveys before and after the treatment. A previous MSSE capstone project (Dresher, 2013) included a student interest survey that was adapted to be used in this project. Suslick (1985), in an article describing a menu-driven class design in an undergraduate college-level chemistry course, also included a shorter student interest survey from which ideas were taken. The first survey mentioned above includes questions relative to student attitudes towards science. The second includes questions relative to student attitudes about a menu-based system of assignments.

The research project and data collection methods were designed to follow the example of Krajcik, McNeill and Reiser (2007), in which the authors used a similar model to determine the effectiveness of a middle school science curriculum. They developed a strategy for designing the curriculum which involved listing the required standards, expanding the various concepts within each standard, developing specific student tasks to address each concept, and finally developing assessment items that were aligned with the tasks. To evaluate the effectiveness of the curriculum, they administered

pre-and post-tests, collected student artifacts such as lab journals, made classroom videos and observations, and administered teacher surveys. A similar model was followed in this project, as is described more fully in the Methodology section of this paper.

There are many published books of ideas about how to differentiate instruction in the science classroom. A few of these contain models that were incorporated into this research project. Westphal (2013) describes different styles of menus that can be used in secondary science classrooms, addresses difficulties that may arise with menus, and explains the creation and use of a general rubric that can be used to grade a variety of student projects. Westphal's template for a list-style menu was used in a modified form for this research project. This type of menu allows for multiple objectives to be addressed, provides for differentiation based on ability and/or prior knowledge, and gives students control over their own activities and grades.

The literature clearly shows benefits both in student attitude and achievement in classrooms where differentiated instruction is implemented. The main goal of this classroom research project was to discover if student menus are an effective way to implement differentiation. This project included a variety of features designed to meet the differing needs of individual students. Constructivist theory states that students need opportunities to apply new knowledge to situations where it can be combined with previous knowledge. The nature of the assignments in this treatment provided those opportunities to the students. Successful differentiation includes ongoing formative assessment, flexible arrangements, and tasks that reflect student needs. The menu design allowed for flexibility in the classroom and tasks that could challenge each student.

## METHODOLOGY

In this project, I taught a total of four 2-3 week units to a combined 7th/8th grade life science class and another four units to a 9<sup>th</sup> grade physical science class. These classes were chosen as representative of the junior high and senior high-level classes in the school. They include a diverse range of students by grade level, gender, academic ability, socioeconomic status, and interests.

The life science class consisted of eleven students; eight eighth graders and three seventh graders. Three of the students are boys and eight of them are girls. One of the students is on an Individualized Education Program (IEP). Two of the students score in the upper tenth percentile on standardized tests.

Two of the units for the life science class (Cell Reproduction and Adaptations Over Time) were taught using a combination of mini-lectures, lab activities, online activities, and written assignments in which the whole class was given the same assignments and was expected to complete them at the same time.

The two treatment units for the class (Heredity and Bacteria) were delivered using a different technique. At the beginning of each of the treatment units, the students were given a list-style menu of activities from which they chose (see Appendix A). They were required to complete enough activities to earn a specific number of points. The activities in each unit addressed different ability levels and learning styles.

The menus were structured in such a way that students must complete activities from 3-6 different categories (one for each of the unit objectives). This ensured that each

student addressed all of the objectives in the unit at least once in their work. The topics for each menu were the main unit objectives for the unit being taught.

During the treatment units, members of the class came together for several (4-5) ten-minute mini-lecture/discussions to introduce new concepts. The remainder of their class time was spent working independently on the activities they chose. When students selected the same lab or project as one or more of their classmates, they were allowed to work in groups on the project if they so desired. The teacher monitored students individually as they worked and provided scaffolding when needed.

The treatment description was the same for the 9<sup>th</sup> grade physical science class, but their nontreatment units were on Atoms, Elements and the Periodic Table and Atomic Structure and Chemical Bonds. The treatment units for the physical science class were States of Matter and Chemical Reactions.

The physical science class consisted of seven ninth-grade students; three girls and four boys. One student in this class is on an IEP and one student scores in the top tenth percentile on standardized tests.

The data collection instruments for this research project included a teacher journal, pre-unit formative assessments, summative unit assessments, classroom observations of student engagement, pre- and post-unit student attitude surveys, student projects, and pre- and post-unit student interviews. The relationship between these instruments and the research questions is illustrated by Table 1.

Table 1  
*Data Collection Techniques*

<b>Focus questions</b>	Teacher Log	Pre-Unit Formative Assessment	Summative Unit Assessment	Classroom Observations of Student Engagement (field notes)	Pre- and Post-Treatment Student Attitude Surveys	Student Projects (Artifacts and Grading Rubrics)	Pre- and Post-Unit Student Interviews
How effective is a menu-driven learning method as measured by students' mastery of unit standards?		X	X	X		X	
What are the effects of a menu-driven learning method on student attitudes towards science?	X				X		X
How does a menu-driven learning method impact the classroom teacher?	X			X		X	

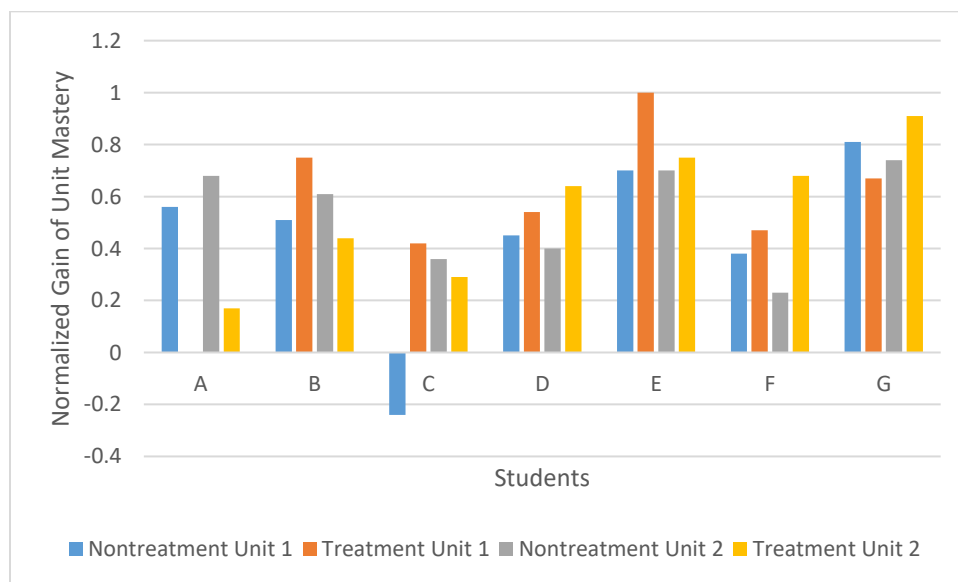
Each of these data collection instruments were designed to address the specific questions in this research project. Each research question was addressed by a minimum of three types of data. The pre-unit and summative assessments were identical written tests given before the beginning of each unit and then again at the end. The tests were assembled by the researcher mostly using exam questions provided by the textbook companies, with modifications when necessary to address specific concepts covered during the unit by the class. Since the same test was given as a formative assessment and again as a summative assessment, any change in a student's score should indicate a change in their knowledge of the content. The same written attitude surveys were given at four points during the research, at the end of each content unit. Again, the questions were the same at each administration. The basic interview questions in the oral interviews were also kept constant throughout the research project, although the follow-up questions varied according to individual student responses and the unit just completed. Each student was

interviewed at the end of each unit during the study. The teacher journal entries followed a basic template, although not all of the questions on the template were addressed every day. Copies of the student attitude surveys, student interview questions, teacher log template, and unit assessments are included as Appendices B-E.

Data collection began on November 1, 2016 and was completed February 8, 2017. The research methodology for this project received an exemption from Montana State University's Institutional Review Board and compliance for working with human subjects was maintained. See Appendix F for the IRB exemption.

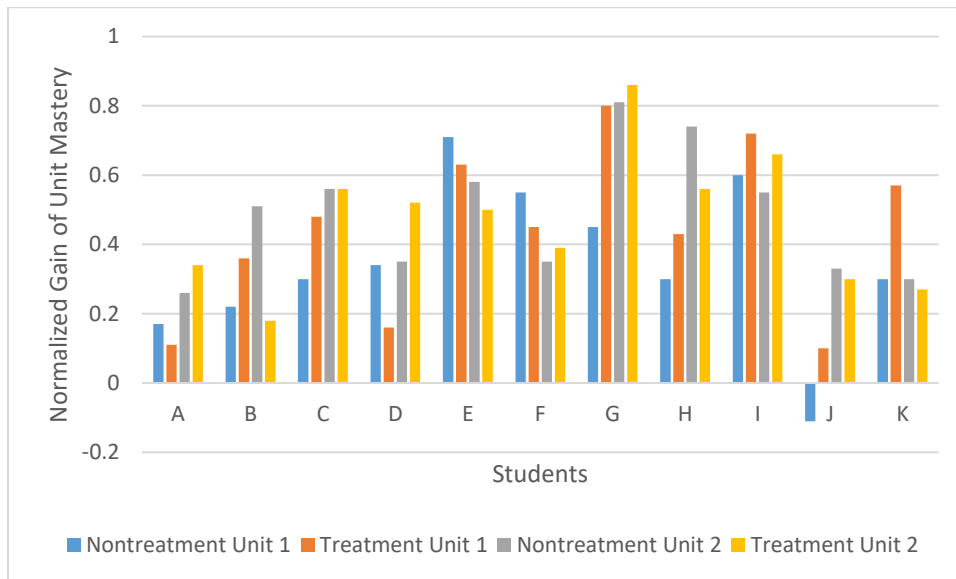
## DATA AND ANALYSIS

Students' mastery of unit standards was measured through their performance on pre-unit and post-unit assessments and their overall average score for the activities completed during each unit. The results of the pre-unit and post-unit tests were converted into normalized gains. The results of these gains are shown in Figures 1 and 2.



*Figure 1.* Normalized gain of physical science students' mastery of content standards in each unit, ( $N=7$ ).



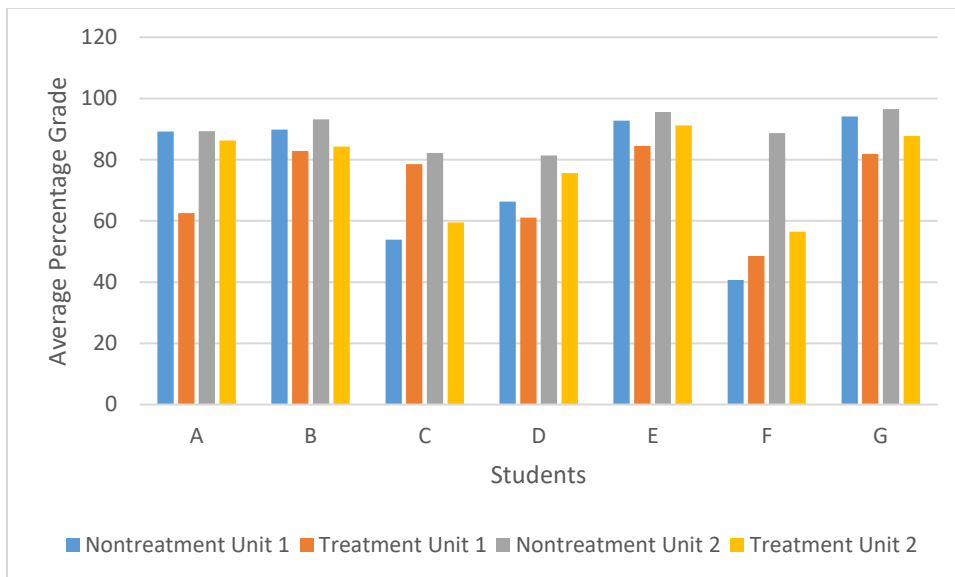


*Figure 2.* Normalized gain of life science students' mastery of content standards in each unit, ( $N=11$ ).

As these figures indicate, there were no overall similarities in achievement pattern related to the treatment versus nontreatment units in either class as a whole as measured by student scores on the unit exams. Several individual students did show a pattern in their achievement related to the treatment units and these are discussed later in this section.

The students' average scores on the activities and assignments in each unit did show a more consistent pattern between the treatment and nontreatment units as is illustrated in Figures 3 and 4. Seventy one percent (5/7) of the physical science students scored higher unit averages in the nontreatment units than the treatment units. Forty-five percent (5/11) of the life science students scored higher unit averages in the nontreatment units than the treatment units. The remaining students in both classes did not seem to show a pattern in their achievement relative to the type of teaching method used. It is

possible that student achievement was somewhat higher overall in nontreatment units because there was more consistent oversight by the teacher of each separate activity and there was more direct presentation of concepts by the teacher in an auditory format. In the nontreatment units, there were almost daily assignments that were graded and returned to students regularly, as well as class lecture or discussion time for a portion of each class period. This did not occur during the treatment units. As will be seen in the analysis of individual students, the menu-driven units seemed to be most difficult for students who prefer an auditory learning style and those who struggle with organization or self-motivation.



*Figure 3.* Physical science student average scores on unit activities in each unit, ( $N=7$ ).

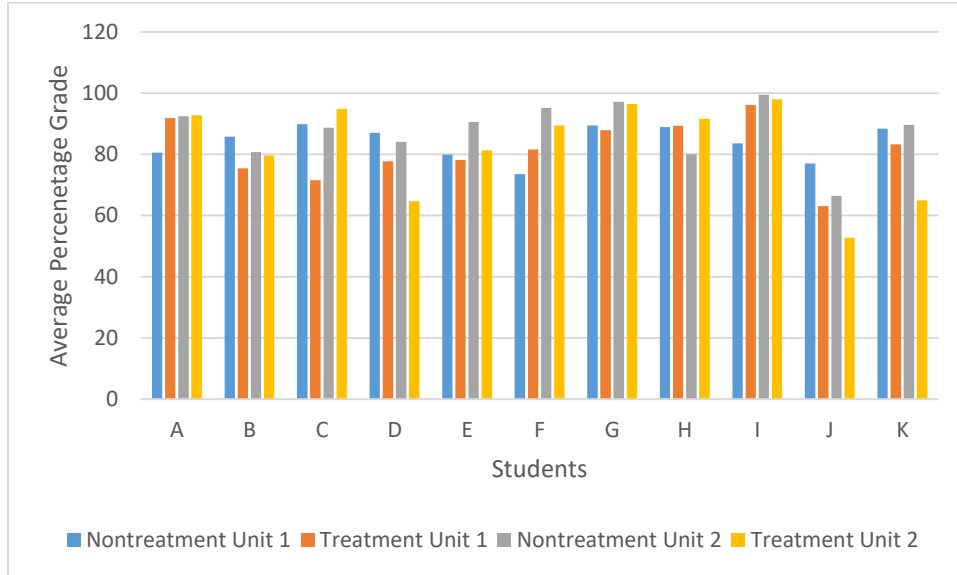


Figure 4. Life science student average scores on unit activities in each unit, ( $N=11$ ).

The preliminary surveys pointed to a difference in general attitude towards science between the two classes. These attitudes can be seen in the initial responses to the Likert-style survey questions which are summarized in Tables 2 (physical science class) and 3 (life science class).

Table 2.

*Preliminary Attitude Survey—Physical Science Class* Note. ( $N=7$ )

Questions	Number of Students with Each Answer				
	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
1. Science lessons are fun.	0 0%	1 14%	4 57%	2 29%	0 0%
2. I am interested in what we study in science class.	1 14%	2 29%	1 14%	3 43%	0 0%
3. I would like to take another science class.	1 14%	1 14%	2 29%	2 29%	1 14%
4. I would like to learn more about science.	1 14%	4 57%	0 0%	1 14%	1 14%
5. I think science classes I take in the future will be interesting.	0 0%	2 29%	3 43%	2 29%	0 0%
6. I would like to be a scientist when I leave school.	0 0%	0 0%	0 0%	5 71%	2 29%

Table 3.  
*Preliminary Attitude Survey—Life Science Class*

Questions	Number of Students with Each Answer/ Percentage of the Class with Each Answer				
	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
1. Science lessons are fun.	0 0%	5 50%	4 40%	0 0%	1 10%
2. I am interested in what we study in science class.	2 20%	2 20%	4 40%	2 20%	0 0%
3. I would like to take another science class.	4 40%	3 30%	1 10%	0 0%	2 20%
4. I would like to learn more about science.	5 50%	3 30%	1 10%	1 10%	0 0%
5. I think science classes I take in the future will be interesting.	3 30%	2 20%	4 40%	0 0%	1 10%
6. I would like to be a scientist when I leave school.	2 20%	0 0%	3 30%	2 20%	3 30%

Note. ( $N=11$ )

As is shown in these tables, only 28% (two students) of the physical science class indicated that they would like to take another science class while 70% (seven students) of the life science class did. In the physical science class, the majority of comments showed a dislike of science in general. Typical comments included “I wouldn’t [like to take another science class] because I’ll just have another bad grade on my report card;” and, “Not really because I tend to struggle with keeping up in the classes.” In the life science class, the majority of comments indicated that the students thought that science was important for the future or that they were just interested in the subject. Some typical comments included: “Because I want to go to medical school, so I want to take as many science classes as I can;” and, “I like plants and animals and climates.” These different attitudes seem to be partly due to the personalities and interests of the individual students. Another factor that might have influenced this result is that three of the seven physical

science students (43% of the class) were new to the school this year. In the life science class, three of the students (27% of the class) were also new to the school this year. Some of the students' attitudes towards science may have been more negative due to past experiences with science classes at other schools or their level of stress while adjusting to a new environment. Based on the results of this research, students who think science is important also tended to like it more.

After completing the series of four attitude surveys, student attitudes towards science did not generally show any overall pattern related to the treatment in either class. For most of the students, their answers stayed the same throughout the study period, or varied in ways unrelated to the treatment. The students' answers to the Likert-style items on the attitude surveys are summarized in Figures 5 (physical science class) and 6 (life science class). When looking at the overall physical science class responses, there was a slight increase in students who agreed with the statement, "Science lessons are fun," when questioned after a treatment (menu) unit; but this change was small. In the life science class, there was a similarly small increase in the number of students who agreed with the statement, "I would like to take another science class," when questioned after the traditionally-taught units as compared to their answers after the treatment (menu) units.

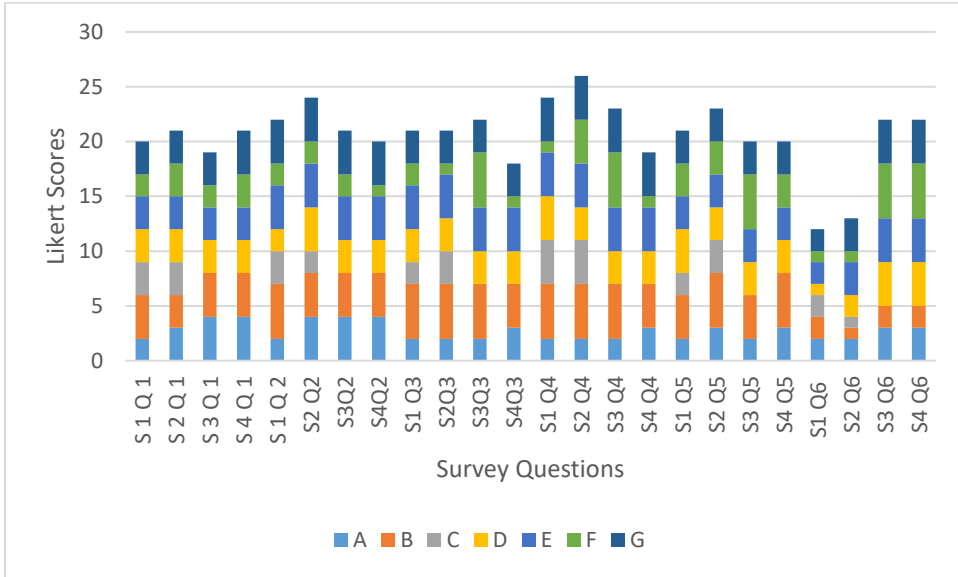


Figure 5. Student answers to Likert-style survey questions—physical science class, (N=7).

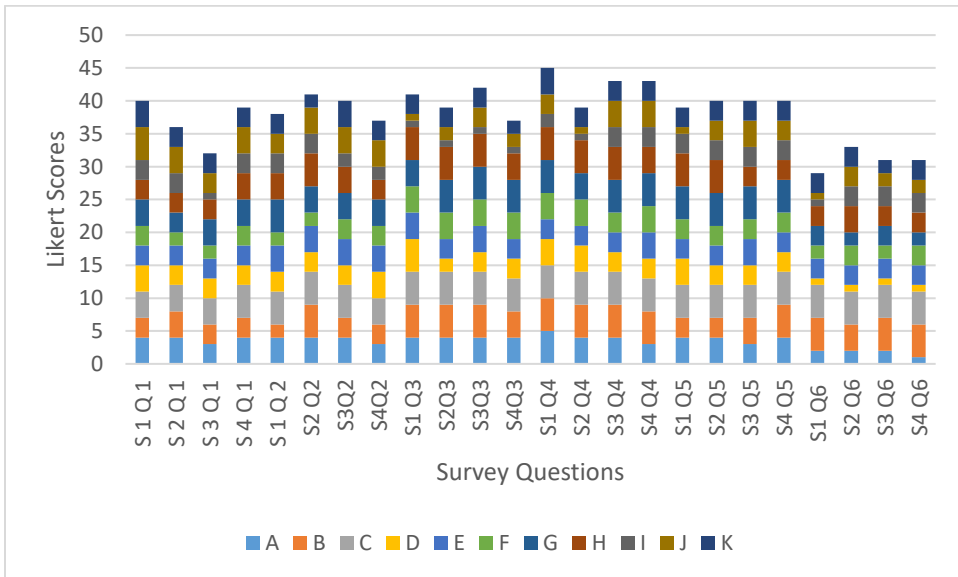


Figure 6. Student answers to Likert-style survey questions—life science class, (N=11).

Although the results of this research did not show any clear connections between student mastery of concepts or attitudes towards science in either class as a whole, there were some interesting patterns in the data collected for a few individual students. Student

A in the physical science class showed a much lower level of normalized gain in the treatment units (0.0 and 0.17) than he did in the nontreatment units (0.56 and 0.68). This pattern seemed consistent with his unit averages, which were 89.2% and 89.3% in the two nontreatment units and which dropped to 62.5% and 86.25% in the treatment units.

When interviewed before the first treatment unit, Student A indicated that he thought having a list of activities to choose from would be a good thing, “because everyone can do a different thing.” His belief had not changed after the first treatment unit when he said he preferred the menu because, “I got to pick my own things and I didn’t have to do the same stuff that someone else picked.” And he indicated that he thought he had learned the material as well as he did during the nontreatment unit. His answers were similar after each of the following two units.

This student did not start with a positive attitude toward science. On the initial attitude survey, for example, he disagreed with the statement, “I would like to learn more about science;” and added the comment, “I don’t like science, and I like math more.” After disagreeing with the statement, “I am interested in what we study in science class,” he added the comment, “It doesn’t interest me that much.” This student was a new student at this school in the fall and was adjusting to his new surroundings. His attitude towards science, as reflected in his survey answers, seemed to improve as the research project went on, irrespective of whether we had completed a treatment unit or a nontreatment unit. After the first treatment unit, he changed four of the six Likert responses from “I disagree” to “I am not sure” or “I agree.” By the end of the final unit in the study, he did not disagree with any of the positive statements about science. His

final comment about the statement, “I am interested in what we study in science class,” was, “It helps me get a better understanding of what I’m supposed to learn.”

Student E in the physical science class showed a more typical pattern, in that her data did not necessarily all point in the same direction. She showed a slight increase in normalized gain on her unit exams during treatment units, from 0.7 on each of the nontreatment units, to 1.0 and 0.75 on the treatment units. Her average grade on the unit activities, however, was somewhat lower during the treatment units (84.5% and 91.1%) as compared to her average grade during the nontreatment units (92.8% and 95.6%).

Student E’s thoughts about menus did change somewhat over the course of the research project. When she was interviewed before the first treatment unit, she indicated that she thought she would be more likely to complete activities and learn from them “if I picked [from a list] probably.” After the first treatment unit, she said that, “some things were easier and some things probably weren’t. . .like getting it all in on time...” After a second nontreatment unit, when asked whether it was easier or harder to understand the unit concepts with a menu, she said, “probably harder. . .because we’re doing it on our own.” During her last interview, at the end of the second treatment unit, she was asked whether she preferred menus, or the traditional approach. Her response was, “It can go both ways. I like them because we can get our stuff done in a certain amount of time, but then again, I don’t, because I feel like I learn a little bit more when you teach us all together in a lab.”

Student E had a generally positive attitude towards science throughout the research project, with most of her Likert responses either, “I am not sure” or “I agree” to



each of the survey questions. A typical response on the first survey was her comment on the statement, "I am interested in what we study in science class." when she wrote, "I like studying chemical science because I enjoy those labs more." The only change in her survey answers was in response to the statement, "I would like to be a scientist when I leave school." She disagreed with this statement on the first survey and added the comment, "Being a scientist really isn't my philosophy." On the second survey, she changed her answer to, "I am not sure" and on the third and fourth surveys, she indicated that she agreed with the statement. Her comment then was, "The job that I have will most likely involve science in some way."

The majority of students in the life science class did not show a pattern in normalized gain related to the treatment or nontreatment units. However, Student I did have a slight increase in her test performance during the treatment units (.72 and 0.66) when compared with the nontreatment units (.6 and 0.55). Her average grade on the unit activities, while not following exactly the same pattern, showed a similar trend (96.1% and 98.0% on the treatment units and 83.6% and 99.5% on the nontreatment units). Student I was a female eighth grade student who scored in the top ten percentile on standardized tests. This student, while generally excelling in science, did not have a positive attitude towards the subject when surveyed. On the first survey, she disagreed with the statement, "I would like to learn more about science", adding the comment that, "I know plenty already." On the same survey, she strongly disagreed with the statement, "I would like to be a scientist when I leave school," commenting, "Science has never been my best subject, and I wouldn't like to spend the rest of my life doing it." By the

last survey, she had changed her answers to, “I am not sure” for both of the above statements. Her comments at that point were that, “Some science is cool but I don’t like most of what I have ever learned about it;” and, “I don’t like science, but a lot of jobs have it.” When interviewed, Student I initially indicated that she would prefer a menu-based unit over a traditionally-taught one because, “. . .you can choose based on your skill. . .” but that, “You might just choose what was really easy for you and not what would push yourself.” After completing the treatment units, she continued to prefer the menu-based units, stating that with menus, “you can figure it out in your own way.” This student seemed to do well with the menu-based units, probably because of her preference for working individually and her high level of self-motivation.

Student D in the life science class was more typical of her classmates. While she did not show a pattern related to the treatment and nontreatment units in her normalized test gain, her average grades in the treatment units (77.8% and 64.7%) were lower than her average grades in the nontreatment units (87.1% and 84.1%). Student D is a female eighth grade student whose standardized test scores and school grades are in the average range. She initially had a positive attitude towards science in general as indicated by her responses on the first survey and interview. On the first survey, she responded that she strongly agreed with the statement, “I would like to take another science class” because. . .”I want to make stuff explode and stuff like that.” Her enthusiasm diminished after the first treatment unit, when, in response to the same statement she disagreed, saying, “ I disagree unless it’s about stuff that blows up or stuff that we get to cut open.” After the second nontreatment unit, she said she was not sure if she would like to take another

science class, commenting, “If I do physics then yes probably.” After the second treatment unit, she again said she was not sure about taking another science class, saying, “I like the teacher, but science isn’t really my thing.”

Her change in attitude was echoed in her responses to the oral interviews. During the initial interview, she indicated that she thought a menu-driven unit would be better for her learning “[be]cause I do things better when I’m doing stuff that I really like to do or want to do.” After the first treatment unit, though, she indicated that she did not like the experience. When asked, “Was there anything good about the menu?” she answered, “No.” When asked what she didn’t like about it she said, “Having all of the assignments at once.” In the later interviews, she held to this view, commenting,

I don’t really like the menu because I feel like we get a lot more done and faster when you’re teaching us. . . because then every day we just have something new instead of having to do it all by ourselves; and I don’t like the menus because, I get behind . . . [because] we don’t have a due date for a certain thing on the menu until the very end.

Student D’s performance and attitudes during the research project seem to be related to her difficulty with organization and her preference for working in groups rather than individually.

Some trends relative to the effect of the menu-based learning method on the classroom teacher were noted during this project. One was a distinct change in the amount of time and the timing of the work required to prepare for lessons and grade student work. During the nontreatment units, an average of 10 minutes was required to plan and prepare for the day’s lesson for each class. During the treatment units, an additional two to three hours of planning was required to design and create the unit

menus. On the first day of the treatment units, an average of 30 minutes was needed to set up the materials that might be needed for the day's class. This extra time was not required on subsequent days as long as it was possible to leave the materials out in the room. The additional preplanning would not be required in subsequent years if the unit were used again, although some alterations to fit the needs of a different class of students might need to be made.

A second change in teacher workload that occurred during the treatment units was caused by the tendency of students to turn in several assignments at the end of the unit when the menus were due. This led to a relatively large number of assignments that need to be graded at one time. During the nontreatment units, assignments were turned in at regular intervals throughout the unit. For example, during the Cell Reproduction unit (a nontreatment unit), the life science students turned in a lab or other project every other day, on average. This created an average of 5.5 assignments to grade per day for the class. At the end of the Heredity Unit, the same class turned in forty assignments in the last two days of the unit that all needed to be graded at once, at the same time that the unit tests were given.

The third major issue related to teacher workload that arose during this project was the difficulty of adequately helping all of the students who requested it in a timely manner. This was most pronounced in the life science class which had a larger number of students. When the class was working on up to eleven different projects simultaneously, it was sometimes difficult to address all of their concerns before the end of the class period. The teacher was able to interact individually with all of the students

present 96% of the time in the physical science class and 92% of the time in the life science class during the nontreatment units, but only 89% of the time in the physical science class and 73% of the time in the life science class during the treatment units. This situation was addressed by having students ask questions of their peers when the teacher was busy with another student and having students come in outside of class time if they were still struggling, but the timeliness of teacher support suffered during the treatment units, particularly in the life science class.

### INTERPRETATION AND CONCLUSION

This research project was intended to address the effectiveness of a menu-driven unit design as measured by students' mastery of unit standards. The results did not show any consistent overall effect, either positive or negative, on most students' achievement. However, for some individual students, such as Student A in the physical science class and Student D in the life science class, their level of concept mastery decreased during the menu-driven units. This type of unit seemed to be most difficult for students who learn best by listening to an auditory lecture-type format and those who have some difficulty with organizing their time and effort to complete multiple assignments in a certain length of time. For a smaller number of students, such as Student I in the life science class, the menu-driven format seemed to increase their level of concept mastery. This student is a highly self-motivated and organized individual who prefers working alone to working with others.

A secondary issue addressed by this research project was the effect of a menu-driven learning method on student attitudes towards their science class and science in

general. What became clear after the initial surveys and interviews was that there was a wide range of attitudes towards science and the science class among the students studied. The physical science class had a slightly more neutral or negative attitude towards science from the beginning, while the life science class began with a generally positive attitude toward science. These differences seemed to stem mostly from the differences in personality and scientific background of each student.

The treatment did not seem to have any direct relationship to students' attitudes toward science in general, but it did tend to decrease their approval of their science class if the student did not like the menu-style units. These changes in attitude towards the science class seemed to be temporary, as most students' responses to the surveys and interviews changed back to more positive ones after subsequent nontreatment units.

The final question addressed by this research project was the effect of menu-driven learning units on the classroom teacher. Based on the results of this project, the overall planning time required for a menu-driven unit is slightly higher than that for a traditional unit. This effect would become smaller, however, if the menus were used over again for a later class. The tendency of students to turn in assignments at the last minute led to a decrease in teacher grading during the treatment units but an increase in grading at the end of them. This situation might be mitigated in future by requiring multiple assignment deadlines within the unit menus instead of having a single deadline at the end of the unit. The most concerning effect on the classroom teacher has been the difficulty of interacting with all of the students during each class period when there are more than five or six different projects going on at once.

## VALUE

The results of this study do not indicate that the use of menu-driven units is either entirely positive or entirely negative as a means of differentiating instruction. However, the majority of the students in the two test classes continued to like several aspects of the menu-driven units, even if they did not perform as well academically during those units. In particular, according to their responses on the oral interviews, they liked having the ability to choose their own activities, either to select things that they especially liked to do or to avoid those that they didn't like. For this reason, there is good reason to use modified menus with future classes. In order to address some of the concerns with the menus that arose during this research project, future menus will be restricted to shorter sections of units, or as a way to review concepts which have already been taught, rather than covering entire units.

Next year, for instance, the teacher will take smaller sections of the Heredity unit menu and use them as review of individual sections within the unit rather than assigning the entire unit's worth of activities at once. Since the topics on the unit menu (1-3 in the case of the Genetics unit) generally correspond with the unit sections, these shorter menus will include between four and six options, from which the students will be able to select two or three. This modification should address student concerns which arose during the treatment unit that the large number of required activities made it challenging to schedule their time and effort appropriately. It will also allow for student progress to be more closely monitored by the teacher throughout the unit.

Another adjustment to the design of the menus which might be helpful in the future is to include multiple assignment due dates for longer (unit-length) menus. This would address two issues which arose during this research and were mentioned above; namely, the difficulty some students had in self-organizing to complete all of their assignments before a single final due date and the difficulty the teacher had in grading the exceptionally large quantity of student work that was turned in at the last minute.

One aspect of the menu-driven unit design which was not directly investigated during this research project, but which arose as a possible topic for further study during the treatments, was the complexity and/or novelty of the material being covered in the unit. Several life science students and the teacher noticed that they had a much easier time with the Bacteria unit menu than they did with the Heredity unit menu. This might have been partially due to the fact that the Bacteria unit was their second experience with a menu and they were more familiar with the expectations. However, a more important factor seemed to be that the Heredity unit covered several complex concepts that were new to these students, whereas the Bacteria unit included simpler concepts that mostly built on ideas that were already familiar to the students. The physical science class did not seem to have the type of discrepancy between the two menu-based units that the life science class did, but the two units covered in the physical science class both included simpler concepts that added to students' prior knowledge of similar ideas. This seems to indicate that the menus may be more suited for use in situations where students possess at least some prior knowledge of the content before using the menu.



Further research could also be done into the efficacy of other differentiation techniques, such as independent projects and tiered assignments that might be used in conjunction with some form of the menus to improve student achievement. These types of differentiation, as referenced in the conceptual framework section, have also been shown to improve student concept mastery.

Since classroom differentiation affects all educators, the results of this study could offer a useful case study of how menus might be used in a variety of situations. Although the sample sizes in this study are not large, this differentiation technique operates at the level of individual students and a sampling of how it affects the performance and attitude of these individuals may provide some idea of how other students might react in a similar circumstance.

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APPENDICES

APPENDIX A  
UNIT MENU TEMPLATE AND TREATMENT MENUS

**Unit Title**

**Guidelines:**

1. You may complete as many of the activities listed as you can within the assigned time period.
2. You may choose any combination of activities, but you must complete at least one activity from each topic area.
3. Your goal is 100 points. You may earn up to \_\_\_\_\_ points extra credit.
4. You may be as creative as you like, within the guidelines listed below.
5. You must share your plan with Mrs. Martin by \_\_\_\_\_.
6. Activities may be turned in at any time during the working time period. They will be graded and recorded on this sheet as you complete them, so don't lose it!
7. All of the activities must be completed no later than \_\_\_\_\_.

Topic	Plan to Do	Activity to Complete	Point Value	Date Completed	Points Earned
Any of the above		Free choice—Submit a proposal form to Mrs. Martin for a product of your choice.			

**Total number of points you are planning to earn: \_\_\_\_\_ Total points earned: \_\_\_\_\_**

Teacher's initials \_\_\_\_\_ Student's signature \_\_\_\_\_

### Physical Science—States of Matter Unit

#### Guidelines:

1. You may complete as many of the activities listed as you can within the assigned time period.
2. You may choose any combination of activities, but you must complete at least one activity from each topic area.
3. Your goal is 100 points. You may earn up to 15 points extra credit.
4. You must share your plan with Mrs. Martin by Wednesday, November 9th.
5. Activities may be turned in at any time during the working time period. They will be graded and recorded on this sheet as you complete them, so don't lose it!
6. All of the activities must be completed no later than Monday, November 21<sup>st</sup>.

Topic	Plan to Do	Activity to Complete	Point Value	Date Completed	Points Earned
1		Molecules on the Move Worksheet	9		
		Molecules in Motion Lab	7		
		Molecules Matter Lab/Heat Temperature and Conduction Lab	29		
		A Matter of Matter Worksheet	9		
		Molecular Motion and Temperature Lab	8		
2		Doing the Atomic Shake Essay and Crossword Puzzle	10		
		Thermal Energy and Matter Lab	20		
3		Lifting an Ice Cube with a String Lab	10		
		Changing State Labs (4 labs)	44		
4		Motion of Atomic Particles Labs (3 Labs)	36		
All		Chapter Note-Taking Worksheets	12		
		Vocabulary Assignment	13		
		Chapter Review Assignment	15		



Total number of points you are planning to earn: \_\_\_\_\_ Total points earned: \_\_\_\_\_

Teacher's initials \_\_\_\_\_ Student's signature \_\_\_\_\_

**Physical Science—Chemical Reactions Unit**

**Guidelines:**

1. You may complete as many of the activities listed as you can within the assigned time period.
2. You may choose any combination of activities, but you must complete at least one activity from each topic area.
3. Your goal is 100 points. You may earn up to 15 points extra credit.
4. You must share your plan with Mrs. Martin by Thursday, December 15th.
5. Activities may be turned in at any time during the working time period. They will be graded and recorded on this sheet as you complete them, so don't lose it!
6. All of the activities must be completed no later than Monday, January 9th.

Topic	Plan to Do	Activity to Complete	Point Value	Date Completed	Points Earned
1		Observing the Law of Conservation of Mass Lab	10		
		Physical or Chemical Change Lab	10		
		Chemical Reactions Lab	17		
2		Balancing Chemical Equations Lab	20		
		Balancing Equations Worksheet	10		
		Another Balancing Equations Worksheet	8		
		Balancing Chemical Equations Ipad Lab	15		
3		Energy Changes in Chemical Reactions Lab	10		
4		A Catalyst and the Rate of Reaction Lab	11		
		Putting on the Heat Lab	17		
		Plop Plop Fizz Fizz Lab	22		
		What is Your Reaction? Lab	17		
All		Chapter Note-Taking Worksheets	17		
		Vocabulary Assignment	12		
		Chapter Review Assignment	12		

**Total number of points you are planning to earn:** \_\_\_\_\_ **Total points earned:** \_\_\_\_\_

**Teacher's initials** \_\_\_\_\_ **Student's signature** \_\_\_\_\_

### Life Science—Heredity Unit

**Guidelines:**

1. You may complete as many of the activities listed as you can within the assigned time period.
2. You may choose any combination of activities, but you must complete at least one activity from each topic area.
3. Your goal is 150 points. You may earn up to 15 points extra credit.
4. You must share your plan with Mrs. Martin by Tuesday, November 22nd.
5. Activities may be turned in at any time during the working time period. They will be graded and recorded on this sheet as you complete them, so don't lose it!
6. All of the activities must be completed no later than Monday, December 12th.

Topic	Plan to Do	Activity to Complete	Point Value	Date Completed	Points Earned
1		Mendelian Genetics Online Lab	10		
		Punnett Square Online Lab	10		
		Hairy Kitty Cat Genes/Kitty Cat Toes (2 labs)	39		
		Pale Cats Problem Lab	20		
		Andromedan Traits and Alleles Worksheet	14		
		Heredity Worksheet Packet—includes an at-home survey	26		
		Inheritance of Traits in Pea Plants Lab	20		
1/2		Mendel's Ideas on Inheritance of Traits Essay and Acrostic Puzzle	14		
2		Black and White and Spots All Over Problem Lab	20		
		Calico Cats Problem Lab	20		
		Cat Puzzles Problem Lab	20		
		How Do Fruit Flies Inherit the Sepia Eye Color Trait? Lab	25		
		The Higgenbothum Hairline Pedigree Lab/Human Pedigree Wksht	17		
		Cystic Fibrosis and Mendel's Law of Segregation Lab	10		
		Flipping Over Color Blindness Lab	10		
		Blood Type and Inheritance Worksheet	10		
3		Human Growth Hormone and Recombinant DNA Lab	10		
		Genetic Engineering Research Project	20		
All		Vocabulary Assignment	15		
		Unit Study Guide	15		

Total number of points you are planning to earn: \_\_\_\_\_ Total points earned: \_\_\_\_\_

Teacher's initials \_\_\_\_\_ Student's signature \_\_\_\_\_

### Life Science—Bacteria Unit

#### Guidelines:

1. You may complete as many of the activities listed as you can within the assigned time period.
2. You may choose any combination of activities, but you must complete at least one activity from each topic area.
3. Your goal is 70 points. You may earn up to 5 points extra credit.
4. You must share your plan with Mrs. Martin by Wednesday, January 25th.
5. Activities may be turned in at any time during the working time period. They will be graded and recorded on this sheet as you complete them, so don't lose it!
6. All of the activities must be completed no later than Monday, February 6<sup>th</sup>.

Topic	Plan to Do	Activity to Complete	Point Value	Date Completed	Points Earned
1		Prokaryote (Bacteria) Worksheet	17		
		Bacterial Cell Models	15		
		Shapes of Bacteria Lab	8		
		Mega Multiples of Microbes Lab	13		
2		Putting Bacteria to Work Video	14		
		Bacteria—The Good, the Bad and Getting Rid of the Ugly Article	10		
		Bacteria Fan Club Project	10		
		The Wanted List Project	10		
3		What's Really Bugging You Article	22		
		Expiration Dates Lab (requires work at home)	11		
		What Kills Germs? Online Lab	12		
		Bacterial Testing Online Lab	11		
All		Chapter Note-Taking Worksheets	18		
		Vocabulary Assignment	11		
		Chapter Review Assignment	14		

Total number of points you are planning to earn: \_\_\_\_\_ Total points earned: \_\_\_\_\_

Teacher's initials \_\_\_\_\_ Student's signature \_\_\_\_\_

APPENDIX B  
STUDENT ATTITUDE SURVEY

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

Name \_\_\_\_\_

### Science Opinion Survey

Read each statement. Circle the statement that most closely matches your opinion of the statement. There are no right or wrong answers.

1. Science lessons are fun.	I strongly agree	I agree	I am not sure	I disagree	I strongly disagree
-----------------------------	------------------	---------	---------------	------------	---------------------

Explain why you chose the answer you did.

2. I am interested in what we study in science class.	I strongly agree	I agree	I am not sure	I disagree	I strongly disagree
---	------------------	---------	---------------	------------	---------------------

Explain why you chose the answer you did.

3. I would like to take another science class.	I strongly agree	I agree	I am not sure	I disagree	I strongly disagree
--	------------------	---------	---------------	------------	---------------------

Explain why you chose the answer you did.

4. I would like to learn more about science.	I strongly agree	I agree	I am not sure	I disagree	I strongly disagree
--	------------------	---------	---------------	------------	---------------------

Explain why you chose the answer you did.

5. I think science classes I take in the future will be interesting.	I strongly agree	I agree	I am not sure	I disagree	I strongly disagree
--	------------------	---------	---------------	------------	---------------------

Explain why you chose the answer you did.

6. I would like to be a scientist when I leave school.	I strongly agree	I agree	I am not sure	I disagree	I strongly disagree
--	------------------	---------	---------------	------------	---------------------

Explain why you chose the answer you did.



APPENDIX C  
STUDENT PRE- AND POST-UNIT INTERVIEW

### Student Pre- and Post-Unit Interview Questions

**Introductory Statement: Participation in this research is voluntary and participation or non-participation will not affect your grades or class standing in any way.**

1. What types of activities help you to learn the most in school? (Prompt with examples if needed, i.e., reading aloud, reading quietly, hands-on labs, problem solving.)

Followup: What are some examples? Can you remember a time in school when you did these? When was that?

2. Name the three things you remember the best from this unit in science.

Followup: Why do you think you remember them? What did you like about them?

3. Would you be (Are you) more or less likely to complete activities in science if you had to choose which activities to do from a list rather than being assigned specific tasks?

Followup: Why do you think so? What do you see as the benefit to that? What problems might you see in doing that?

APPENDIX D  
TEACHER LOG BOOK TEMPLATE

To be used in the daily entries during the research period:

Date:

Class Period:

Was I able to interact with each student individually today? \_\_\_\_\_

How long did the setup and planning for today's class take? \_\_\_\_\_

Notes on Student Engagement during class (on-off-task behavior):

Things that went well during today's class:

Things that didn't go well during today's class:

What would I do to improve the outcome of today's lesson tomorrow?

How might I change the design of today's lesson in the future (if necessary)?

APPENDIX E  
PRE-AND POST-UNIT ASSESSMENTS FOR TREATMENT AND  
NONTREATMENT UNITS

## Life Science

## Cell Reproduction Unit Test

## Multiple Choice (1 point each)

Write the letter of the correct answer in the blank next to each question number.

- \_\_\_\_\_ 1. Most of the life of any cell is spent in a period of cell growth and development called \_\_\_\_.
- A. interphase  
B. metaphase  
C. prophase  
D. telophase
- \_\_\_\_\_ 2. All of the following are composed of body cells **EXCEPT** \_\_\_\_.
- A. bone  
B. kidney  
C. liver  
D. sperm
- \_\_\_\_\_ 3. Each human skin cell has \_\_\_\_ pairs of chromosomes.
- A. 13  
B. 18  
C. 23  
D. 46
- \_\_\_\_\_ 4. Human sex cells have \_\_\_\_ individual chromosomes.
- A. 13  
B. 23  
C. 33  
D. 46
- \_\_\_\_\_ 5. In sexual reproduction, a new organism is produced when \_\_\_\_.
- A. cells divide by mitosis  
B. sex cells combine  
C. an organism divides into two equal parts  
D. a new organism grows from the body of its parent
- \_\_\_\_\_ 6. By \_\_\_\_, a new organism can grow from just a part of the parent organism.
- A. fission  
B. meiosis  
C. regeneration  
D. sexual union
- \_\_\_\_\_ 7. The number of chromosomes in a sex cell of an organism is its \_\_\_\_ chromosome number.
- A. one  
B. haploid  
C. RNA  
D. zygote
- \_\_\_\_\_ 8. Meiosis consists of \_\_\_\_ division(s) of the nucleus
- A. one  
B. two  
C. three  
D. four
- \_\_\_\_\_ 9. At the end of meiosis, \_\_\_\_ cells have been produced from one cell.
- A. two  
C. four

B. three

D. five

\_\_\_\_\_ 10. Proteins are made of units called \_\_\_\_\_, which are linked together in a specific order.

A. amino acids

C. centromeres

B. centrioles

D. ribosomes

\_\_\_\_\_ 11. The code for making proteins is carried to the ribosomes by \_\_\_\_\_.

A. tRNA

C. mRNA

B. DNA

D. thymine

\_\_\_\_\_ 12. In DNA, adenine always pairs with \_\_\_\_\_.

A. cytosine

C. thymine

B. guanine

D. uracil

\_\_\_\_\_ 13. Which of the following is a double spiral molecule with pairs of nitrogen bases?

A. RNA

C. protein

B. amino acid

D. DNA

\_\_\_\_\_ 14. When do chromatids separate during mitosis?

A. anaphase

C. metaphase

B. prophase

D. telophase

\_\_\_\_\_ 15. During a cell's life cycle, when do chromosomes duplicate?

A. anaphase

C. interphase

B. metaphase

D. telophase

Short Answer Questions

1. For each of the following, tell whether it describes mitosis, meiosis, or both. (6 points)

a. used to make body cells \_\_\_\_\_

b. used to make sex cells \_\_\_\_\_

c. produces new cells with each having half as many chromosomes as the original cell

\_\_\_\_\_

d. occurs in both plants and animals \_\_\_\_\_

e. has eight steps in cell division \_\_\_\_\_

f. has four steps in cell division \_\_\_\_\_

2. Can a mutation in a human skin cell be passed on to the person's offspring? Explain your answer. (2 points)
  
3. List the base sequence of a strand of RNA made using the following DNA pattern: (1 point)  
ATCCGTC
  
4. What is a mutation? Give examples of when mutations could be harmful, beneficial, or neutral. (3 points)
  
5. Plants grown from runners and leaf cuttings have the same traits as the parent plant. Plants grown from seeds can vary from the parent plants in many ways. Why does this happen? (2 points)
  
6. Why is it important for the nuclear membrane to disintegrate during mitosis? (1 point)

**Longer Answer Question (5 points)**

1. Describe the relationship between genes, proteins, DNA, and chromosomes.



## Life Science

## Heredity Unit Test

## Multiple Choice (1 point each)

Write the letter of the correct answer on the line in front of each question.

- \_\_\_\_\_ 1. In a Punnett square, a capital letter stands for a \_\_\_\_ allele.
- A. dominant  
B. heterozygous  
C. recessive  
D. sex-linked
- \_\_\_\_\_ 2. The combination Tt represents a \_\_\_\_ genotype.
- A. heterozygous  
B. homozygous  
C. purebred  
D. sex-linked
- \_\_\_\_\_ 3. Experiments with four o'clock flowers produced examples of \_\_\_\_ dominance when red flowered plants were crossed with white flowered plants and their offspring had pink flowers.
- A. heterozygous  
B. homozygous  
C. incomplete  
D. recessive
- \_\_\_\_\_ 4. Blood type is an example of
- A. multiple alleles  
B. a pair of genes  
C. polygenic inheritance  
D. sex-linked genes
- \_\_\_\_\_ 5. Color blindness is an example of \_\_\_\_.
- A. a sex-linked disorder  
B. incomplete dominance  
C. probability  
D. polygenic inheritance
- \_\_\_\_\_ 6. Genetic engineering has already helped people by \_\_\_\_.
- A. altering pedigrees.  
B. curing Down's syndrome.  
C. eliminating infant deaths.  
D. producing medicine.
- \_\_\_\_\_ 7. Through recombinant DNA, scientists have been able to \_\_\_\_.
- A. cure color blindness.  
B. create new breeds of dogs.  
C. alter viruses.  
D. improve tomatoes.
- \_\_\_\_\_ 8. What separates during meiosis?
- A. proteins  
B. phenotypes  
C. alleles  
D. pedigrees
- \_\_\_\_\_ 9. What controls traits in organisms?
- A. cell membrane  
B. cell wall  
C. genes  
D. Punnett square



A. Dominant: chin cleft (C)  
Recessive: no cleft (c)  
Parents: CC x cc

B. Dominant: dimples (D)  
Recessive: no dimples (d)  
Parents: Dd x Dd

## Life Science

## Adaptations Over Time Unit Test

## Multiple Choice (1 point each)

Write the letter of the correct answer on the line in front of each number.

\_\_\_\_\_ 1. The (incorrect) hypothesis that species evolve by keeping traits that their parents developed during their lives was proposed by \_\_\_\_.

- |            |              |
|------------|--------------|
| A. Darwin  | C. Laughlin  |
| B. Lamarck | D. Slaughter |

\_\_\_\_\_ 2. The theory of \_\_\_\_ states that organisms with traits best suited to their environment are more likely to survive and reproduce.

- |                             |                             |
|-----------------------------|-----------------------------|
| A. acquired characteristics | C. natural selection        |
| B. embryology               | D. survival of the smartest |

\_\_\_\_\_ 3. Variations are important in populations because they can lead to \_\_\_\_.

- |                        |                 |
|------------------------|-----------------|
| A. better environments | C. more fossils |
| B. less evolution      | D. new species  |

\_\_\_\_\_ 4. The movement of individuals into or out of a population provides a source of \_\_\_\_ to a population.

- |                           |               |
|---------------------------|---------------|
| A. mutations              | C. variation  |
| B. punctuated equilibrium | D. camouflage |

\_\_\_\_\_ 5. Most fossils are found in \_\_\_\_.

- |                 |                     |
|-----------------|---------------------|
| A. bones        | C. sedimentary rock |
| B. igneous rock | D. wood             |

\_\_\_\_\_ 6. Scientists can estimate the age of a fossil by comparing the amount of \_\_\_\_ with the amount of \_\_\_\_.

- |                                  |  |
|----------------------------------|--|
| A. sediment; radioactive element | C. sediment; fossils                           |
| B. fossils; variation            | D. radioactive element; nonradioactive element |

\_\_\_\_\_ 7. The fossil record is \_\_\_\_.

- |              |                |
|--------------|----------------|
| A. vestigial | C. unimportant |
| B. complete  | D. incomplete  |

\_\_\_\_\_ 8. All of the following EXCEPT \_\_\_\_ provide evidence for evolution.

- |                             |                         |
|-----------------------------|-------------------------|
| A. homologous structures    | C. vestigial structures |
| B. acquired characteristics | D. embryology           |

\_\_\_\_\_ 9. What is an example of adaptation?

- A. a fossil
- B. gradualism
- C. camouflage
- D. embryo

\_\_\_\_\_ 10. Which model of evolution describes change over a relatively short period of time?

- A. embryology
- B. adaptation
- C. gradualism
- D. punctuated equilibrium

### Short Answer Questions

1. List three types of evidence that support the theory of evolution. (3 points)
  - A.
  - B.
  - C.
2. List two of the principles of natural selection. (2 points)
  - A.
  - B.
3. What evidence would you use to determine whether the evolution of a group was best explained by gradualism? How would this differ from a group that followed a punctuated equilibrium model? (2 points)
4. Describe what type of bill a seed-eating bird might have. Be specific. You may draw a picture if you would like. (1 point)





- A. endospores  
 B. saprophytes  
 C. antibiotics  
 D. nitrogen-fixing nodules
- \_\_\_\_\_ 11. Most bacteria reproduce by \_\_\_\_\_.
- A. budding  
 B. mating  
 C. fission  
 D. spore formation
- \_\_\_\_\_ 12. A common name for cyanobacteria is \_\_\_\_\_ bacteria.
- A. black-green  
 B. blue-green  
 C. green  
 D. yellow-green
- \_\_\_\_\_ 13. Helpful bacteria can do all of the following EXCEPT \_\_\_\_\_.
- A. produce antibiotics  
 B. kill viruses  
 C. clean up oil spills  
 D. make cheese and yogurt
- \_\_\_\_\_ 14. It is estimated that \_\_\_\_\_ save farmers several million dollars in fertilizer costs each year.
- A. archaeobacteria  
 B. nitrogen-fixing bacteria  
 C. saprophytes  
 D. eukaryotes
- \_\_\_\_\_ 15. The gel-like substance covering some cyanobacteria enables them to \_\_\_\_\_.
- A. live in extreme environments  
 B. live together in colonies  
 C. cause diseases  
 D. form food products

### Short Answer Questions

Bacteria live in groups called colonies. Colonies are usually circular. The diameter of a particular bacterial colony is 10 mm. The circumference of a circle is equal to  $\pi$  (3.14) times its diameter or  $\pi$  times twice the circle's radius ( $C = \pi d$  or  $C = 2\pi r$ ).

1. What is the circumference of the colony? (1 point)
2. What is the radius of the colony? (1 point)

Pretend you are a scientist studying two diseases. You notice that people in your study who have had disease Y never get disease X even when they are exposed to it.

3. What can you hypothesize about disease Y? (1 point)



4. How could you test your hypothesis? (2 points)

5. Label the parts of the bacterium below using the words from the word bank.

**Word Bank**

cell membrane

cell wall

chromosome

cytoplasm

flagellum

gelatinlike capsule

ribosome

**Longer Answer Questions**

1. Describe at least three helpful uses of bacteria. (3 points)

A.

B.

C.

2. Explain how some bacteria cause disease. Make sure to describe at least two ways. (2 points)

3. List three places where you might find anaerobic bacteria living. (3 points)

A.

B.

C.



**More Matching (1 point each)**

\_\_\_\_\_ 1. The particle in the nucleus of the atom which has a positive charge and which is counted to determine the atomic number

\_\_\_\_\_ 2. The new substance formed when elements combine chemically

\_\_\_\_\_ 3. Two atoms that have the same number of protons but different numbers of neutrons

\_\_\_\_\_ 4. The particle in an atom which has a negative charge and helps determine the atom's reactivity

\_\_\_\_\_ 5. The particle in the nucleus of the atom which has no electric charge and which helps to hold the atom together

- A. Isotopes
- B. Neutrons
- C. Protons
- D. Electrons
- E. Compound

**More Short Answer Questions**

1. List two characteristics of metals. (2 points)
  
  
  
  
  
  
  
  
  
  
2. Using the periodic table, answer the following questions. (1 point each)  
  
What are the atomic numbers of:
  - a. Carbon
  - b. Nickel  
What are the chemical symbols of:
  - a. Calcium
  - b. Lead  
What is the atomic mass of:
  - a. Chlorine
  - b. Hydrogen
  
3. An atom has the atomic number 36. What element is it? (1 point)
  
  
  
  
  
  
  
  
  
  
4. What do you call the rows in the periodic table? (1 point)
  
  
  
  
  
  
  
  
  
  
5. What do you call a mixture in which all of the substances are the same throughout? (1 point)
  
  
  
  
  
  
  
  
  
  
6. An atom of chlorine has a mass number of 35.
  - a. How many protons are in the nucleus of this atom? (1 point)
  
  
  
  
  
  
  
  
  
  
  - b. How many electrons are in this atom? (1 point)

c. How many neutrons are in the nucleus of this atom? (1 point)

7. Another atom of chlorine has a mass number of 37. How many neutrons are in this atom? (1 point)

**Physical Science****States of Matter Unit Test****Matching (1 point each)**

Match each number with the correct letter from the right hand column. All of the letters will be used more than once.

- \_\_\_\_\_ 1. Has a definite volume but no definite shape
- \_\_\_\_\_ 2. Can expand or be compressed
- \_\_\_\_\_ 3. Takes on the shape of whatever container it is in, but does not necessarily fill it
- \_\_\_\_\_ 4. Particles in it are held tightly together and vibrate in place
- \_\_\_\_\_ 5. Flows
- \_\_\_\_\_ 6. Does not have a definite volume or a definite shape
- \_\_\_\_\_ 7. Particles in it slide past one another, but don't move very far apart
- \_\_\_\_\_ 8. Does not take the shape of the container it is placed in
- \_\_\_\_\_ 9. Particles have a lot of energy and move far apart from each other

\_\_\_\_\_ 10. Takes the shape of whatever container it is placed in and fills it

A. Solid

B. Liquid

C. Gas

**Short Answer Questions**

1. When does matter change from one state to another? (1 point)
  
2. Which has a higher viscosity, water or honey? (1 point)
  
3. What is the melting point of water (in degrees Celsius)? (1 point)

4. Name two changes of state that release energy. (2 points)

**More Matching (1 point each)**

Match each number with the correct letter in the right hand column. Each letter will only be used once.

- |  |                   |
|--|-------------------|
| _____ 1. The movement of thermal energy from a substance at a higher temperature to one at a lower temperature | A. specific heat  |
| _____ 2. The change from a solid to a liquid state   | B. vaporization   |
| _____ 3. The ability to do work or cause change  | C. heat           |
| _____ 4. The total kinetic and potential energy of all the particles in a sample of matter                     | D. sublimation    |
| _____ 5. The amount of thermal energy needed to raise the temperature of 1 gram of a substance 1°C             | E. thermal energy |
| _____ 6. The change from a liquid state to a solid state   | F. melting        |
| _____ 7. The change from a solid directly to a gaseous state   | G. freezing       |
| _____ 8. The average kinetic energy of the individual particles in a sample of matter                          | H. energy         |
| _____ 9. The change from a gas to a liquid   | I. condensation   |
| _____ 10. The change from a liquid to a gas  | J. temperature    |



## Physical Science

## Atomic Structure and Chemical Bonds Unit Test

## Matching (1 point each)

Match each statement below with the correct word or words that describe it.

- |   |                         |
|---|-------------------------|
| _____ 1. Most of the mass of an atom is located here  | A. Electron cloud       |
| _____ 2. The area of space around the nucleus of an atom where electrons are found  | B. Ion                  |
| _____ 3. A vertical column on the periodic table  | C. Polar molecule       |
| _____ 4. Group 1 elements; they have one electron in their outer energy levels  | D. Nucleus              |
| _____ 5. Formed when an atom gains or loses one or more electrons   | E. Electron dot diagram |
| _____ 6. Group 18 elements; they are very stable and do not react easily with other elements  | F. Group or family      |
| _____ 7. Occur when two or more atoms share electrons unequally; one side of the bond is more negative than the other                                     | G. Halogens             |
| _____ 8. A combination of chemical symbols and numbers that shows which elements are present in a compound and how many atoms of each element are present | H. Noble gases          |
| _____ 9. Group 17 elements; they have seven electrons in their outer energy levels  | I. Chemical formula     |
| _____ 10. Consists of the symbol of an element surrounded by as many dots as there are electrons in its outer energy level                                | J. Alkali metals        |

## Fill in the Blank (1 point each)

Fill in the blanks with *ionic bond*, *covalent bond*, or *metallic bond*. Each answer may be used more than once.

- \_\_\_\_\_ 1. Usually include at least one nonmetal atom which has four electrons in its outer energy level



4. Write the chemical formulas for the following compounds: (1 point each)
- 1 atom of carbon and 4 atoms of hydrogen (methane)
  - 1 atom of hydrogen, 1 atom of sulfur, and 4 atoms of oxygen (sulfuric acid)
  - 6 atoms of carbon, 12 atoms of hydrogen and 6 atoms of oxygen (glucose)
  - 2 atoms of nitrogen (nitrogen)
5. If equal masses of  $\text{CuCl}$  and  $\text{CuCl}_2$  decompose into their components—copper and chlorine—predict which compound will yield more copper. Explain. (2 points)

## Physical Science

## Chemical Reactions Unit Test

## Multiple Choice (1 point each)

Write the letter of the choice that best completes each statement.

- \_\_\_\_\_ 1. The presence of a(n) \_\_\_\_\_ speeds up a reaction.
- |             |              |
|-------------|--------------|
| A. reactant | C. product   |
| B. catalyst | D. inhibitor |
- \_\_\_\_\_ 2. Heat is absorbed during \_\_\_\_\_ reactions.
- |                |               |
|----------------|---------------|
| A. activation  | C. enzyme     |
| B. endothermic | D. exothermic |
- \_\_\_\_\_ 3. Substances formed during chemical reactions are \_\_\_\_\_.
- |              |              |
|--------------|--------------|
| A. catalysts | C. reactants |
| B. oxides    | D. products  |
- \_\_\_\_\_ 4. A \_\_\_\_\_ is a process in which new substances are formed.
- |                      |              |
|----------------------|--------------|
| A. chemical reaction | C. reactant  |
| B. catalyst          | D. subscript |
- \_\_\_\_\_ 5. The melting of ice is an example of a(n) \_\_\_\_\_.
- |                         |                        |
|-------------------------|------------------------|
| A. chemical change      | C. exothermic reaction |
| B. endothermic reaction | D. physical change     |
- \_\_\_\_\_ 6. For a chemical reaction to begin, \_\_\_\_\_ is needed.
- |               |                      |
|---------------|----------------------|
| A. combustion | C. activation energy |
| B. a catalyst | D. a spark           |
- \_\_\_\_\_ 7. The rate of reaction in a chemical change can be measured by how fast a(n) \_\_\_\_\_ appears.
- |             |             |
|-------------|-------------|
| A. reactant | C. exotherm |
|-------------|-------------|

B. activator

D. product

\_\_\_\_\_ 8. Adding an inhibitor tends to \_\_\_\_\_ a reaction.

A. slow down

C. speed up

B. stop

D. reverse

\_\_\_\_\_ 9. Chemical reactions usually speed up at \_\_\_\_\_ temperatures.

A. celsius

C. higher

B. lower

D. absolute

\_\_\_\_\_ 10. Reactants have their highest concentrations \_\_\_\_\_ a chemical change takes place.

A. after

C. both A and B

B. before

D. neither A nor B

### Short Answer Questions

1. A beaker of water in sunlight becomes warm. Has a chemical reaction occurred? Explain your answer. (2 points)

2. Use the equation below to help answer the question. (1 point)

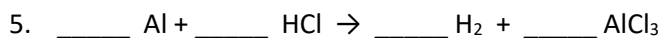
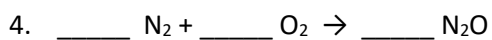
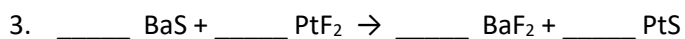
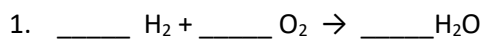


When solutions of calcium chloride ( $\text{CaCl}_2$ ) and silver nitrate ( $\text{AgNO}_3$ ) are mixed, calcium nitrate ( $\text{Ca}(\text{NO}_3)_2$ ) and a white precipitate, or residue, form. Determine the chemical formula of the precipitate.

3. Is activation energy needed for reactions that release energy? Explain why or why not. (2 points)

**Fill in the Blank**

Balance the following equations. (2 points each)

**Longer Answer Question (5 points)**

1. You are cleaning out a cabinet beneath the kitchen sink and find an unused steel wool scrub pad that has rusted completely. Will the remains of this pad weigh more or less than when it was new? **Explain.**

APPENDIX F  
IRB EXEMPTION FORM



**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
**FWA 0000165**

960 Technology Blvd. Room 127  
 c/o Microbiology & Immunology  
 Montana State University  
 Bozeman, MT 59718  
 Telephone: 406-994-6783  
 FAX: 406-994-4303  
 E-mail: cherylj@montana.edu

*Chair:* Mark Quinn  
 406-994-4707  
 mquinn@montana.edu  
*Administrator:*  
 Cheryl Johnson  
 406-994-4706  
 cherylj@montana.edu

**MEMORANDUM**

**TO:** Diane Martin and Walter Woolbaugh

**FROM:** Mark Quinn *Mark Quinn cy*

**DATE:** September 30, 2016

**RE:** *"The Effectiveness of a Menu-driven Learning Method as Measured by Students' Mastery of Unit Standards"*  
 [DM093016-EX]

The above research, described in your submission of **September 30, 2016**, 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:

- (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.
- (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.