HOMEWORK THAT HELPS:
IDENTIFYING ASPECTS OF MEANINGFUL BIOLOGY
HOMEWORK ASSIGNMENTS

by

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Robin A. Cameron

July 2012
Thank you to the MSSE faculty and staff for the invaluable advice, instruction, wisdom, and timely responses to emails, and a sincere thanks to my capstone committee of John Graves, Pati Glee, Kim Naegele, and Peggy Taylor. Thank you to my husband, Phil, for his encouragement and delicious meals on long nights of writing, and to my dog, Charley, for reminding me when it was time to take a break and get some exercise. Finally, thank you to the introductory biology students, their parents, and the faculty and staff at Jackson Hole Community School for their cooperation and support during my classroom research.
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Homework assignments were evaluated to see which types of assignments improved concept retention and increased the interest of diverse learners in introductory biology classes. The assignments were differentiated with attention to multiple intelligences, integration of the arts, non-textbook readings, and inquiry. The efficacy of these homework assignments was evaluated through a variety of instruments, including pretests and posttests, responses to journal prompts and surveys, and field notes. Students communicated that homework assignments were a valuable extension of classroom learning. They appreciated different types of homework assignments for varied reasons, including assignments they did not label as fun.
INTRODUCTION AND BACKGROUND

My capstone project took place during my seventh year of teaching introductory biology at the Jackson Hole Community School (JHCS), a small, independent school in Jackson, Wyoming. The school was in its 8th year of operation with 14 full-time faculty members employed and 85 students enrolled in grades 9 through 12. I was the only biology teacher, and the average JHCS class size was 10 students (“FAQs,” n.d.). Seven percent of the students were non-Caucasian, and about 65% of the students received financial assistance from the school. JHCS is committed to serving all students interested in being part of a unique learning community and focuses on preparing students from a variety of backgrounds for college and life beyond.

Twenty students (19 10th graders and 1 11th grader) were enrolled in two sections of the introductory biology course, which emphasized the importance of asking questions and making observations while developing an understanding of the living world. Through indoor laboratories and field experiences, the course investigated five units: the nature of life, ecology, cells, genetics, and evolution. Students were asked to draw connections between what they studied and current biological issues in Jackson and around the globe through a wide variety of assignments in and out of the classroom.

Students requested more variety in homework assignments and asked to complete fewer questions from the textbook. After interviewing students, I decided to make a concerted effort to increase variety in the types of homework assignments with more awareness to individual student needs, in order to improve the effectiveness of my introductory biology course.
Commitment to maximizing the benefits of homework led to my primary focus question: What types of homework assignments will improve concept retention and increase the interest of diverse learners in my introductory biology class? While answering this question, I investigated trends related to concept retention and positive response to differentiated homework assignments that incorporated multiple intelligences, integration of the arts, non-textbook readings, technology, and inquiry.

CONCEPTUAL FRAMEWORK

Homework has the potential to be a valuable component of the high school learning process. When assigned properly, homework can increase the amount of information retained, emphasize that school is not the only place where learning occurs, and improve study skills and attitudes towards school and learning in general (Cooper, 2001). Homework extends learning outside of the classroom and should not be eliminated from the daily routine of students (Marzano & Pickering, 2007). Educators can use homework assignments to help achieve their classroom goals and improve students’ chances of academic success (Simplico, 2005).

An evaluation of research from 1987 to 2003 concluded that the average student who completed relevant homework performed 23 percentile points above a student in a class where homework was not assigned, highlighting a stronger relationship for 7th to 12th graders than kindergarteners to 6th graders (Cooper, Robinson, & Patall, 2006). In the high school environment, a direct relationship exists between positive academic progress and time spent on homework. However, too much homework each night could begin to have negative effects (Cooper, 2001). Alleman et al. (2010) concluded that
when homework is intentionally designed with the needs of students in mind, more positive effects than negative effects result. Therefore, teachers should focus more energy on assigning differentiated homework that addresses a variety of learning styles and less energy on filling time parameters outlined in school homework policies.

In order for homework to be effective, it is crucial for teachers and schools to adopt homework policies that consider the needs of the student population being served (Cooper, 2001). Further, Marzano and Pickering (2007) promoted the proper use of homework by teachers and suggested schools evaluate and, if necessary, improve homework policies to prevent teachers from assigning unbeneficial homework and potentially decreasing the chances of academic success for their students. Clearly communicating and executing homework policies will aid in minimizing potential conflicts arising between teachers, students, and parents surrounding homework, while simultaneously maximizing the chance of student achievement resulting from homework completion (Marzano, Pickering, & Pollock, 2001).

Homework effectiveness is linked to the time teachers invest in creating and choosing assignments. Teachers must design homework as well as assign it, and the design process demands attention to all aspects of assignments to best engage students and help them succeed (Epstein & Van Voorhis, 2001). Marzano and Pickering (2007) requested that teachers consider the following guidelines when structuring homework assignments:

- Ask students to complete homework with a clear purpose, including introducing new material, practicing skills that students are capable of
completing on their own, deepening understanding of topics addressed in class, and encouraging time to explore topics of student interest.

• Create engaging, reasonable, and relevant assignments, increasing the likelihood of student completion.

• Consider useful ways to involve parents.

• Track the amount of homework, to ensure it is not interfering with opportunities to participate in extracurricular activities.

If the intent of the homework assignment is to practice material that has already been taught, the students need to be capable of the tasks involved to avoid practicing improper techniques, instilling misconceptions, creating frustration, and promoting inefficient work habits. To increase student completion of assignments, homework goals must be clearly communicated to ensure the students understand why they are being assigned specific tasks (Marzano et al., 2001). In addition, homework assignments may have a wide variety of purposes and drawing connections between the time put into homework and student success can be challenging (Epstein & Van Voorhis, 2001). Cooper et al. (2006) stressed that the effect of homework on the students’ academic success depends upon the amount of homework assigned and the amount each student completes.

When designing productive homework assignments, it is important to consider techniques that successfully engage students in a classroom, as students are more likely to complete assignments that interest them and seem useful. In addition, class content and teaching style must relate directly to homework (Vatterott, 2009). For example, if differentiation in the classroom improves a teacher’s ability to reach a particular student, it also makes sense to differentiate homework. Differentiation is the expectation that a
teacher identifies the particular needs of individual students and teaches a class with each student in mind, rather than just treating all students the same (Tomlinson & Allan, 2000). Tomlinson and Allan emphasized that if differentiation is effective, teachers and students will be rewarded with progress from each student. Tomlinson and Strickland (2005) described a unit developed by Andrea Strank in a resource guide for differentiated curriculum that demonstrated differentiation in one of Strank’s earth science units. The differentiation revolved around the readiness of students, which she determined by using pre-assessments, small group activities organized by learning profiles, and research projects centered around student interests (Tomlinson & Strickland, 2005).

The diversity of students deserves as much attention as the content to be covered, and if the learners’ needs are ignored, most likely the content goals will not be reached. Since trying to plan with the needs of each student in mind can be unrealistic, Tomlinson and McTighe (2006) suggested teachers use methods that are likely to be successful with a variety of learning styles. In addition, learning becomes more accessible when the ways that students learn best are considered (Vatterott, 2010). Tomlinson and McTighe also recommended keeping questions in mind like, “How might I learn more about these particular students as I watch them interact with the content and the ways in which I set about to teach it?” (p. 23). Students are typically more engaged when teachers are able to implement an assortment of teaching methods, as the variety introduces an element of surprise and some methods are more suitable for different teachers’ goals, class material, and students’ needs (Tomlinson & McTighe, 2006). Vatterott included a compelling quote that highlighted the need for teachers to assign meaningful homework, “As a teacher once said, ‘I never heard of a student not doing his work; it’s our work he’s not
doing.’ When we customize tasks to fit student learning styles and interests, the task becomes theirs, not ours” (p. 12).

One way to ensure homework does not seem repetitive and to lessen student perception that the assignments are busywork is to deliberately integrate different learning styles, which simultaneously allows teachers to differentiate. Attention to Howard Gardner’s multiple intelligences research should inspire teachers to be creative with the tasks students complete for homework. Gardner (1999) defined “intelligence” as a biopsychological potential to process information that can be activated in a cultural setting to solve problems or create products that are of value in a culture” (pp. 33-34). Addressing a variety of intelligences allows teachers to foster engaged students who will experience academic success (Nolen, 2003). Gardner (1993) highlighted the importance of using assessments that encourage students to present their understanding of the material in ways that compliment their intelligences, and he mentioned that more varied assessments can inspire self-assessment, a crucial skill during life beyond school. Gardner identified nine different intelligences that help people learn (Table 1).
Table 1  
*Intelligences as Described in Gardner’s Intelligence Reframed*

<table>
<thead>
<tr>
<th>Intelligence</th>
<th>Strengths</th>
</tr>
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<tbody>
<tr>
<td>1. Linguistic Intelligence</td>
<td>“…sensitivity to spoken and written language, the ability to learn languages, and the capacity to use language to accomplish certain goals” (Gardner, 1999, p. 41).</td>
</tr>
<tr>
<td>2. Logical-Mathematical</td>
<td>“…capacity to analyze problems logically, carry out mathematical operations, and investigate issues scientifically” (Gardner, 1999, p. 42).</td>
</tr>
<tr>
<td>Intelligence</td>
<td></td>
</tr>
<tr>
<td>4. Bodily-Kinesthetic</td>
<td>“…potential of using one’s whole body or parts of the body…to solve problems or fashion products” (Gardner, 1999, p. 42).</td>
</tr>
<tr>
<td>Intelligence</td>
<td></td>
</tr>
<tr>
<td>5. Spatial Intelligence</td>
<td>“…potential to recognize and manipulate the patterns of wide space…as well as the patterns of more confined areas” (Gardner, 1999, p. 42).</td>
</tr>
<tr>
<td>6. Interpersonal Intelligence</td>
<td>“…capacity to understand the intentions, motivations, and desires of other people and, consequently, to work effectively with others” (Gardner, 1999, p. 43).</td>
</tr>
<tr>
<td>7. Intrapersonal Intelligence</td>
<td>“…capacity to understand oneself, to have an effective working model of oneself-including one’s own desires, fears, and capacities- and to use information effectively in regulating one’s own life” (Gardner, 1999, p. 43).</td>
</tr>
<tr>
<td>8. Naturalist Intelligence</td>
<td>“…expertise in the recognition and classification of the numerous species-flora and fauna- of his or her environment” (Gardner, 1999, p. 48).</td>
</tr>
<tr>
<td>9. Existential Intelligence</td>
<td>“…capacity to locate oneself with respect to such existential features of the human condition as the significance of life, the meaning of death, the ultimate fate of the physical and psychological worlds, and such profound experiences as love of another person or total immersion in a work of art” (Gardner, 1999, p. 60).</td>
</tr>
</tbody>
</table>
All students have the potential to develop the intelligences that are less instinctive, so teachers should strive to create a learning environment that will foster maturity in a variety of intelligences (Nolen, 2003). A reliable way to address multiple learning styles is to approach all concepts through a range of teaching methods (Vondracek, 2009). By using a model composed of a mix of investigations, discussions, lectures, models, applications, videos, homework assignments, and assessments, Vondracek asserted that he is able to ensure the material is accessible to all of his students, no matter what learning styles they possess. Vondracek (2009) also acknowledged the importance of not relying upon the same strategies for every unit throughout the year to ensure that students are interested in the curriculum being taught. Alleman et al. (2010) suggested students will pursue the topics that interest them most, and “extensions to a well-designed homework assignment will flow naturally if students are given freedom to follow through on their own questions that spring from it” (p. 57). In addition, when sufficient opportunities exist for students to customize their learning, academic success will result.

For students to maximize their potential, choice of assignments should be prioritized to allow them to utilize their intelligences. When choice of topic or approach is offered, students are more apt to draw personal connections between their lives and the content. Teachers should utilize the strongest intelligences of students to access the material initially and then deliberately follow up with exercises that promote strengthening of the less developed intelligences. Therefore, if all intelligences are considered when planning a unit, students can learn the material while also improving their confidence and abilities to employ diverse intelligences (Ozdemir, Guneysu, &
Tekkaya, 2006). Ozdemir et al. (2006) administered a study to determine the effect of multiple intelligence theory on long-term retention in fourth grade students studying the diversity of organisms. The results of the study revealed students demonstrated better long-term retention when multiple intelligences were considered during the unit.

Technology can also be used in the classroom as a way to address multiple learning styles. Since technology is altering how people think, teachers should update their methodologies. Deliberate use of technology has the potential to positively affect student achievement. If a priority of teachers is to address the learning styles of all students, multiple lessons for addressing single topics may need to be created to best accommodate all students. However, the result will be more students who are engaged and experiencing progress in the classroom (McCoog, 2007). If technology can stimulate students in the classroom, it also has the potential to increase student interest in homework assignments and course content.

Integration of artistic assignments is another way to access students with varied intelligences and learning needs and who believe they are not good at science. Arts education can improve development of basic academic skills and enhance sophisticated learning skills, increasing academic success for all students (Mikow-Porto, 1998). Through incorporation of activities that involve sketching and by bringing an art teacher into the science classroom, students are reminded that it is important to be imaginative and have good observation skills in both the arts and sciences (Terry, 2005). Arts integration has the potential to engage students that are typically disinterested in material conveyed by conventional science teaching methods (Mikow-Porto, 1998). Students who are more comfortable with artistic projects will gain confidence in their scientific skills
when asked to approach scientific material through creative assignments that maintain the same learning objectives. In addition, some students commented that if they had not been able to explore science through art skills, they would have failed their science courses (Hall, 2005). Hall elaborated that content comprehension improved and several students who had failed science were able to pass during the term when emphasis was placed on allowing students to utilize artistic strengths. For example, the necessary patience used when drawing specimens demands more time with the objects and, therefore, students develop a more in-depth understanding of the material and are able to generate more thoughtful questions and hypotheses (Weekes, 2005). As a result, teachers are able to engage more students whose right-brained tendencies are less likely to respond to traditional science teaching methods (Hobart, 2005).

Another effective way to pique students’ interest in a science classroom is through the use of inquiry, so incorporating inquiry-based homework assignments should also increase students’ excitement for material. Inquiry-based instruction is defined as, “the creation of a classroom where students are engaged in essentially open-ended, student-centered, hands-on activities” (Colburn, 2000, p. 42). Teachers do not share anticipated results with the students in order to promote student discovery. In inquiry scenarios, students design the problem and the procedure, and the students should feel like they are executing real science. The teacher must be comfortable with the potential that several different studies may be taking place at once as a result of student-designed experiments (Colburn, 2000). Heppner, Kouttab, and Croasdale (2006) began their discussion of inquiry with D. L. Haury’s belief that inquiry is the best way for students to concurrently develop sophisticated thinking skills and acquisition of new scientific content. When
inquiry-based labs are facilitated addressing the same concepts and using the same
materials of labs that are not inquiry-based, students are given more control over the
design and discovery of information and more learning results (Fay & Bretz, 2008).

The incorporation of inquiry-based labs and other assignments has been
successful in many classrooms, since students carry out the steps of science
investigations in an authentic manner (Fay & Bretz, 2008). Integration of inquiry-based
assignments demands a shift in the teacher’s role, as he/she must become more focused
on facilitating the learning process, rather than directly delivering the concepts through a
more traditional lecture style (Heppner et al., 2006). When students experience this type
of authentic scientific experience, they are likely to be engaged and understand the
purpose of their homework assignments, while being more likely to complete the work as
well. Take-home assignments that incorporate the principles of inquiry-based learning
will likely facilitate connections between the students’ lives and the course content too.

Integrating non-textbook readings can be an effective way to increase student
engagement in and comprehension of scientific material as well, and these readings may
also help students connect to new concepts. Austin, Menasco, and Vannette (2008)
described a positive student response to Bill Bryson’s *A Short History of Nearly
Everything* in their science classes, as the students found the mandatory readings to be
engaging and comprehensible. The students were so fascinated by the material presented
in the book that they requested to read more than was required. Not only did this
approach present the scientific material in an appealing manner, it also served to improve
general literacy skills. Bryson’s writing style was popular and the teachers were pleased
because the content was accurate and provided background on relevant scientific
concepts. The teachers intentionally assigned the readings after the material was presented in class, and the majority of students completed the reading assignments when they were optional because they found them to be so helpful (Austin et al., 2008). Another example of implementing non-textbook readings is asking students to find current event articles that relate to class material. Ricard (2007) reported that 95% of 90 students surveyed responded that they enjoyed the time allocated during class to read about current events, noting these assignments increased their understanding of scientific current events. If students liked completing this type of assignment during class, current events could also be an interesting and valuable homework assignment.

Regardless of the type of homework students are asked to complete, it is necessary to check that students are capable of the skills needed to successfully complete the homework and the assignments actually advance student understanding or enthusiasm, rather than increase frustration or boredom with the content. If students cannot complete the assignments on their own, they are apt to ask their parents for help, leading to tense moments at home and negative experiences for both the students and parents (Kohn, 2006). In addition, when students think homework assignments are busywork, there is less of a chance that they will do the work (Vatterott, 2009). Developing unique and engaging assignments with clearly communicated purposes should minimize how often students become frustrated or rush through assignments to merely receive the completion grades that teachers may award instead of grades based on quality, a concern that Simplico addressed. Being more deliberate with homework assignment design and communication of goals increases the chance that students will complete their homework and meet the teachers’ goals for the assignment.
Cooper et al. (2006) suggested the need for “mixed research models that incorporate qualitative analyses— to examine the homework process, moderators, and mediators of its effects, along with its intended and unintended consequences— in experimental designs” (p. 54). In addition, the following variations need to be investigated to further understand best practices for assigning and designing homework:

- Students with “varying ability levels;”
- Homework assignments for classes other than reading and math;
- “Measures of the non-achievement-related effects of homework that have been proposed in the literature; and
- Variations in the amount of homework assigned, so that optimum amounts of homework can be examined” (Cooper et al., 2006, p. 54).

In general, regardless of the assignment type, homework should be graded and teachers should experiment with types of feedback depending upon the nature of the assignment and the amount of time available for grading (Marzano et al., 2001). H. J. Walberg (1999) completed a study during which the effects of homework fluctuated depending upon whether or not the assignments were graded. When the homework was graded and not just assigned, homework grades increased by 28%. Homework grades further increased by 31% when teachers added written comments to the assignments (Walberg, 1999). However, it is imperative that the students feel comfortable telling their teachers they had difficulty with their homework and that their grades will not be penalized if they express they were confused about an assignment (Vatterott, 2010). Students also communicated that they valued teacher feedback and appreciated when teachers followed up on homework assignments (Cushman, 2010).
When proper energy is put towards designing, assigning, and reviewing homework, the assignments may increase the interest levels of students and improve comprehension of scientific material in high school students, while lessening the concern that homework does not help students learn (Vatterott, 2009). Teachers must recognize the role they play in ensuring that homework is beneficial, keeping in mind a statement from Vatterott, “What if, instead of focusing on the student’s homework behavior, we looked at the teacher’s homework behavior” (p. 72). In order to assist students in becoming confident, self-reliant, and curious life-long learners, teachers must assign homework that students will be motivated to complete. According to Vatterott (2010), “Meaningful homework should be purposeful, efficient, personalized, doable, and inviting” (p. 15). Assignments that meet the needs of individual students should provide evidence against the statement of Kohn (2006) that homework “may be the single most reliable extinguisher of the flame of curiosity” (p. 17). Even the students that Cushman (2010) interviewed acknowledged that if teachers are thoughtful about the homework that they assign, students can learn new material and skills.

METHODOLOGY

Treatment

During the treatment period, homework styles were differentiated consistently. Homework assignments for each section of textbook chapters were designed with attention to multiple intelligences, arts integration, non-textbook readings, technology and inquiry-based science. In addition to textbook assignments, other homework styles were emphasized per chapter as outlined in Table 2.
<table>
<thead>
<tr>
<th>Ecology Unit</th>
<th>Homework Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystems and Communities</td>
<td>Textbook</td>
</tr>
<tr>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Humans in the Biosphere</td>
<td>X</td>
</tr>
<tr>
<td>Cell Structure and Function</td>
<td>X</td>
</tr>
<tr>
<td>Cell Respiration and Fermentation</td>
<td>X</td>
</tr>
<tr>
<td>Cell Growth and Division</td>
<td>X</td>
</tr>
<tr>
<td>Genetics Unit</td>
<td>Introduction to Genetics</td>
</tr>
<tr>
<td>DNA</td>
<td>X</td>
</tr>
</tbody>
</table>

To identify which styles of homework assignments students believed were useful for learning new content and eliciting student enthusiasm prior to the treatment period, students responded to the Preliminary Homework Interview (Appendix A). Throughout the treatment, students completed the chapter specific pretests and posttests at the beginning and end of each chapter, such as the Cellular Respiration Pretest and Posttest, to show whether or not progress occurred with the content addressed in each chapter.
The Chapter Homework Survey asked students to rate how each specific homework assignment furthered their understanding of content, if completion of the assignment was fun, and if they would like to do more assignments like each assignment being assessed in the future. Students also completed the Chapter Journal Prompts to reflect on ways that specific homework assignments and other class assignments may have helped with content retention and increasing interest in the material. Lastly, for each chapter, I recorded notes in my Treatment Journal regarding completion rate for each homework assignment and general attitudes of students before and after completion of homework assignments.

Data Collection

Twenty students in two sections of introductory biology participated in this project. The research was executed from November to March during the second, third, and fourth units of the course. These units focused on ecology, cells, and genetics. All participating students and their parents completed an informed consent form. In addition, 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.

At the beginning of the treatment, all students completed the Multiple Intelligences Inventory found at [http://surfaquarium.com/MI/inventory.htm](http://surfaquarium.com/MI/inventory.htm) to determine learning intelligences based on their own perceived strengths. The results of the survey were compiled and graphed to see which intelligences dominated the classes and to aid in finding trends between students’ strengths and preferred types of homework assignments.
Next, six students responded to the Preliminary Homework Interview. During the interview selection process, students’ names were divided into three groups based on the grade they earned in biology during the first quarter. Students were chosen randomly from each of the groups until there was an even gender balance. The final criterion was that the student shared a free or lunch period with me, so I could avoid interviewing the students before or after school.

At the start of each chapter, the students completed a pretest and later completed the same assessment as a posttest, such as the Cellular Respiration Pretest and Posttest. These pretests were used to discover misconceptions, identify relevant prior knowledge, and highlight the areas that would need the most attention. The results for each pretest were compiled, graphed, and analyzed to identify trends among the students’ responses. At the end of each chapter, the same test was administered as a posttest and results were graphed; average posttest scores were compared to average pretest scores and trends were recorded. A total of seven sets of pretests and posttests were administered, as seven chapters were covered during the treatment period.

At the end of each chapter, students also responded to the Chapter Journal Prompts (Prompts). One hundred percent participation for the Prompts occurred; therefore, 120 sets of Prompts were completed (20 students for 6 chapters, because this tool was not used for the Humans in the Biosphere chapter). These responses were read, and notes were recorded in my Treatment Journal (Journal) to summarize the students’ sentiments regarding the different types of homework assignments and their perceptions of whether or not the assignments for that chapter helped them learn the content.
Finally, students completed the Chapter Homework Survey (Survey). The results of the Survey were coded and analyzed to look for trends in the types of homework assignments that students found useful and engaging and to note student attitudes regarding different types of homework assignments. One hundred percent participation for the Survey occurred; therefore, 140 Surveys were completed (20 students for all 7 chapters).

When homework assignments were introduced, discussed, and collected, I made field notes in my Journal to record students’ comments about the different types of homework assignments and to note attitude changes and which assignments were most and least popular. All previously described data collection methods for each question are outlined below in Table 3.

Table 3  
Data Triangulation Matrix

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Types of assignments that increase retention of concepts?</td>
<td>Multiple Intelligences Survey</td>
<td>Pretest and Posttest</td>
<td>Attitude Scale</td>
<td>Student Journal</td>
</tr>
<tr>
<td>2. Types of assignments that increase interest of diverse learners?</td>
<td>Active Participant Observation-Field notes</td>
<td>Attitude Scale</td>
<td>Student Journal</td>
<td>Student Interview</td>
</tr>
</tbody>
</table>

DATA AND ANALYSIS

Trends emerged from the results of the Multiple Intelligences Inventory (Inventory) that highlighted a full range of intelligence strengths and weaknesses, both from the averaged group data and from the range of individual data about students’
strongest and weakest intelligences. When the students’ results were averaged and compared, the participants’ strongest intelligences were musical, bodily-kinesthetic, and intrapersonal (Figure 1); whereas the weakest intelligences were naturalist and linguistic ($N = 20$). The group averages also revealed a fairly balanced distribution of results for all nine of the intelligences.

Figure 1. Average Scores For Each Intelligence, ($N = 20$).

The full range (highest and lowest) of intelligences scores for participants were graphed to evaluate frequencies reported on the Inventory. Results demonstrated that there was more variety in the responses for each intelligence than the averages revealed (Figure 2). Twenty-five percent of the participants’ results showed more than one intelligence as their highest score, and 35% showed more than one intelligence as their lowest score, which accounts for the higher number of total response points graphed in Figure 2 than the number of students responding to the Inventory. Results indicated strengths and weaknesses in all nine intelligences.
Figure 2. Frequency of Intelligences as High and Low Scores, \((N = 20)\).

The aforementioned data led to development and implementation of 41 homework assignments for the 7 chapters covered during the treatment period. The variety of homework assignments was unevenly distributed by chapter (Figure 3). There was at least one textbook-based homework assignment for every chapter, and for five of the seven chapters, there were more textbook assignments than other types of assignments. For the other two chapters, there were the same number of textbook assignments as those of a different style.
Fifty-six percent of the 41 homework assignments were textbook-based assignments, while the other 44% were composed of assignments that incorporated multiple intelligences, arts integration, inquiry, technology, and non-textbook readings (Figure 4).
When asked if specific homework assignments helped further understanding of the content, the most frequent response for 100% of the homework assignments for all chapters was that the students agreed that all assignments helped further their understanding. During the Preliminary Homework Interview, one student expressed sentiments that supported the benefits of varied homework assignments, “I prefer assignments that do not use the textbook, but the textbook work is good for learning things.” In response to the Chapter Journal Prompts (Prompts), a different student wrote, “All of the homework assignments help further my knowledge.” However, student responses to this question varied greatly (Figure 5). Forty-six percent of the responses to the Prompts mentioned textbook based assignments, while the next most mentioned type of assignments was non-textbook readings with 21% of the responses.
Figure 5. Types of Homework Students Listed as Helping With Content, \((N = 20)\).

Thirteen percent of the responses to the Prompts credited the multiple intelligences assignments, in which students designed their own assignments according to their strengths highlighted in the Inventory. One student commented, “The self-designed vocab review [helped develop understanding of the material] because I was able to focus on what I needed to learn.” An example of a poem written for a multiple intelligences assignment is included in the Three Examples of Student Work (Appendix F). Inquiry assignments were mentioned the least at 1%, but inquiry assignments only accounted for 5% of the 41 assignments (Figure 4). To highlight the benefits of completing different types of assignments, one student added, “All the homework assignments furthered my understanding. The textbook work helped the most and the chapter mystery [from the textbook] helped the least, but each provided insight into the topic.”

To account for the uneven frequency of assignment types offered for each chapter, the ratio of student response frequency (how often a type of assignment was mentioned) to frequency of assignment type (how often a type of assignment was given)
was examined. Students’ responses for which assignments helped to learn the content revealed preferences towards the multiple intelligences, technology, and arts integration assignments, as higher values revealed stronger preferences than lower values (Figure 6). Non-textbook readings and inquiry-based assignments showed a lower preference.

Figure 6. Student Response and Assignment Frequency Ratio for Learning Content, \(N = 20\).

In response to the Prompts that asked about furthering student interest in the material, similar patterns were observed to the responses about developing understanding of content (Figure 7). The type of assignment that received the fewest mentions were inquiry-based, which accounted for 1%. However, the one student who appreciated an inquiry based assignment stated, “Chargaff’s DNA data [an inquiry-based assignment] helped me see a real life experiment.”
Thirty-one percent of the assignments that increased interest focused on arts integration, and the next most referenced were textbook assignments, which were highlighted 26% of the time. One of the popular arts-based assignments asked students to create a mock Facebook page for a specific geneticist. One student explained, “The Facebook page for Frederick Griffith increased my interest, because I became really aware of how important all these people were to each other’s studies.” This student’s Facebook page is included in the Three Examples of Student Work. Non-textbook readings accounted for 15% of the responses, and 1 student recalled a specific article when she commented, “The natural antifreeze reading [increased my interest] because animal adaptations interest me.” A different student explained why she liked designing her homework assignment, “The self made assignment [increased my interest] because we got to let our creativity ‘flow’ to come up with an idea that would help us learn better,” and another student added, “Our self-designed homework [increased my interest], because it was my choice so I was interested.”
Again, the ratio of student response frequency to frequency of assignment types was examined for student answers to which assignments increased interest in the material. Based on the higher values revealing a stronger preference than lower values, students’ responses revealed stronger preferences towards the assignments involving technology, arts integration, multiple intelligences, and non-textbook reading assignments (Figure 8). The observation that non-textbook reading was among the preferred types for increasing interest in the material was in contrast to the low preference ratio in response to helping with learning content (Figure 6). The weakest relationship was found with inquiry-based assignments, and textbook assignments were the second weakest.

![Figure 8. Ratio of Student Response and Assignment Frequency for Increasing Interest, (N = 20).](image)

Observations of data from specific chapters uncovered trends in students’ preferences for different types of homework assignments as well. Percent breakdown of assignment types by chapter highlighted that for two chapters, Cellular Respiration and
Cell Structure and Function, 80% of the assignments were textbook based, and 20% were multiple intelligences and arts integration respectively (Figure 9).

![Graph showing percent frequency of assignment types by chapter.]

Figure 9. Percent Frequency of Assignment Types by Chapter.

Students’ responses to the Prompts about increased content comprehension revealed that even though many more textbook assignments were completed, they found the multiple intelligences assignment to be nearly as helpful as the textbook assignments for the Cellular Respiration Chapter (Figure 10). For the Cell Structure and Function Chapter, the arts integration assignment was mentioned 33% of the time despite the arts integration assignment only making up 20% of the assignments offered.
Different results were observed for these chapters in response to the Journal question that asked about increasing interest in the material. For the Cellular Respiration Chapter, the textbook assignments made up the majority of the responses, as they were mentioned 55% of the time (Figure 11). However, the arts integration assignment made up 50% of the responses and the textbook assignments were noted only 27% of the time for the Cell Structure and Function Chapter.
For chapters where textbook assignments accounted for about 50% of the offered assignments, results showed preferences towards arts integration, technology, and non-textbook reading assignments (Figure 12). Textbook assignments accounted for 32% of the responses for 2 chapters and 17% for the 3rd chapter. However, one student responded that none of the homework increased his interest, “because I was interested from the beginning.”

![Figure 12](image.png)

*Figure 12. Assignments that Increased Interest for Chapters with About 50% Textbook Assignments, \(N = 20\).*

When students were asked if they could have learned the material as successfully if they had not been asked to complete homework assignments for each chapter, 89% of the responses stated that having homework assignments helped them learn the content. “I wouldn’t have been able to keep up in class without absorbing material at home,” added one student, while another student explained, “[homework assignments] provide the necessary components to learn the material.”
Students’ responses to the Chapter Homework Survey revealed that they saw value in the assignments, even if they didn’t always enjoy them. “The homework assignments, while not always fun, are helpful, forcing you to learn the material,” explained one student. When students were asked if specific assignments were fun to complete the responses varied substantially (Figure 13). Fifty-one percent responded as undecided, while 42% of students agreed that the assignments were fun to complete. Of all 41 assignments, only 1 assignment received strongly agree as the most common response to the question of whether it was fun to complete. This assignment, which was believed to be the most fun, was an assignment called Create-A-Critter, during which students were asked to develop a species that was supremely adapted to a specific biome. An example of one student’s Critter is included in the Three Examples of Student Work. One student explained why she liked completing this assignment with the following statement, “It was a lot of fun to design an animal that would be able to live in that area but looks nothing like what lives there.” The students clearly enjoyed this assignment, as many students excitedly asked if they could share their critters and mentioned that they wanted to see their peers’ creations. The fact that every student completed this assignment with strong effort by the due date, resulting in a class grade average of a 97%, also highlighted that it was a popular assignment.
Clear trends emerged when the assignments were examined by type, as far as whether or not they were fun to complete. One hundred percent of the students believed that the technology and multiple intelligences assignments were fun (Figure 14). In response to a computer based mouse breeding exercise, one student stated, “I really liked that homework. It was like playing a computer game.” Seventy-eight percent of the responses were undecided regarding whether they enjoyed completing textbook-based assignments, and the responses regarding inquiry-based assignments highlighted that students were undecided about how fun these assignments were too.
Student recognition that homework assignments helped them learn the material was also supported by the data that resulted from a question asking if students wanted similar assignments in the future. For 87% of the assignments, students agreed, agreed/strongly agreed, or strongly agreed that they would like to complete more assignments like the ones they were evaluating (Figure 15).
Students overwhelmingly agreed that they wanted to do more homework assignments similar to previous textbook, multiple intelligences, arts integration, and technology assignments (Figure 16). However, they were undecided regarding whether or not they wanted to do more inquiry-based assignments, and students were undecided regarding 40% of the non-textbook reading assignments. Students only strongly agreed that they wanted a similar assignment for one assignment, which was the previously described Create-A-Critter. One student mentioned that the Critter “was pretty fun to do and share.” A different student added, “The biome critter drawing helped me understand characteristics of biomes and why and how animals adapt.”

Figure 16. Desired Future Assignments Organized by Assignment Type, \( N = 20 \).

Pretest and posttest results for all chapters revealed that comprehension of the content improved (Figure 17). The largest change of 35% between the pretest and posttest scores was exhibited during the Cell Structure and Function chapter and the smallest change of 1% resulted during the Cell Growth and Division chapter.
While the overall pretest and posttest scores revealed that comprehension improved during all chapters, the majority of students improved their scores from pretests to posttests in six of the seven chapters included in the treatment (Figure 18). However, during the Cell Growth and Division chapter, 40% of the students scored lower on their posttests. Thirty-percent of the students in this chapter earned better scores on their posttests, and the remaining 30% of students earned the same scores. Twenty percent of the students earned 100% on the pretest for this chapter, which was the highest percentage of perfect pretest scores for any of the chapters.
While the data showed that students valued the homework assignments and that student comprehension increased during the units, students also highlighted that the following activities helped them learn the content: participating in labs and discussions, taking notes, playing games, completing crossword puzzles and other handouts, watching films, reviewing and testing by oneself, and participating in group review sessions (Figure 19). Participating in labs and class discussions each made up 22% of the responses to the question that asked what other activities helped you learn the material. One student commented, “Labs [help with learning the material] because at first, you don’t really know what’s going on, and then later you make the connections.” Another student added, “More interactive things help because they keep you engaged.” Twenty percent of the responses credited test review sessions with bettering content comprehension.
INTERPRETATION AND CONCLUSION

Each student highlighted ways that the homework assignments helped them learn the material at some point during the treatment, which suggested the students did not feel like they were completing busywork and understood that homework can effectively enhance learning outside of a classroom environment (Marzano & Pickering, 2007). The collected data demonstrated that in classes composed of students with varied learning strengths, students’ preferences for homework assignments will be varied as well.

*Figure 19. Other Types of Assignments Credited with Helping to Learn Material, (N = 20).*
The results from the Chapter Homework Survey highlighted the mixed preferences, as no distinction was found between assignments that incorporated arts integration, multiple intelligences, non-textbook readings, inquiry, or technology when it came to furthering student comprehension.

It is not surprising that the students did not think all of the assignments were fun to complete. However, they communicated that the less fun assignments still benefited their knowledge acquisition. Since the students communicated that the majority of assignments that incorporated multiple intelligences, arts integration, technology and non-textbook readings were enjoyable to complete, in addition to useful for learning the content, I will continue to incorporate these types of assignments to ensure the students stay engaged and to prevent homework assignments from feeling repetitive or like a burden.

The percent breakdown of assignment types highlighted that I assigned more textbook assignments than other types of assignments, so the high percentage of responses that credited textbook assignments as helping with content may partially be a result of the fact that the majority of assignments offered were textbook related. I will continue to be creative and deliberate with homework assignments, particularly focusing on incorporating less textbook and more inquiry assignments. Inquiry-based assignments were most likely incorporated less, because I use inquiry-based assignments in the classroom, but this was my first attempt at trying inquiry-based homework assignments. The students were undecided regarding whether or not they would like to have more inquiry-based homework assignments in the future, which I believe is a result of the fact
that these open ended assignments were challenging to complete. Inquiry-based assignments work well in my classroom when I am present to help redirect the students at crucial moments to avoid reaching a state of frustration (Colburn, 2000; Kohn, 2006; Vatterott, 2009). Therefore, I think it is possible to create effective inquiry-based homework assignments, but I may need to be more explicit when introducing these assignments to highlight the specific goals and my expectations.

In addition, I would like to incorporate more technology-based homework assignments. The students enjoyed all of the homework assignments that used technology and thought they helped with learning the material. Assuming I can figure out how to prepare students’ computers with the necessary plug-ins to avoid technological roadblocks, I will assign more technology-based homework assignments in the future. The students’ positive responses to many homework types suggest that it is worth taking the time to design homework assignments with several goals in mind (Epstein & Van Voorhis, 2001; Marzano & Pickering, 2007). However, it is important to add that the students also appreciated learning from the straightforward textbook-based assignments, so it is not necessary to eliminate these assignments.

Although the majority of individual posttest scores showed improvement, the pretest and posttest results from the Cell Growth and Division chapter revealed a concerning number of worse posttest scores. However, since this chapter also had the highest percentage of perfect scores on the pretest, the recipients of those scores had no room to improve, which may explain why there was a higher percentage of scores that decreased or stayed the same. In addition, these results align with students’ comments that this chapter’s content was particularly challenging, so I will pay close attention to in-
class and out of class assignments for this chapter next year. It is necessary to recognize that the students credited many other assignments besides homework assignments with helping them learn the material, so it is important to be as thoughtful with the planning of the in-class assignments as the design of homework assignments.

Finally, all pretests and posttests were composed of true or false questions and a few questions that involved circling the correct answers, so some students may have chosen their responses simply by guessing. Therefore, despite the ease of grading and facilitating the format I used, it could be beneficial to add some brief short answer responses if administering pretests and posttests in the future.

VALUE

Implementing this action research project proved to be valuable for several reasons. Since I began my teaching career in a high school classroom, the most common piece of feedback I received on course evaluations was that there should be less textbook-based homework assignments. This project provided me with the needed structure to push myself to further investigate this topic, and with careful exploration, it became quite clear that textbook assignments may be less fun than others, but they are still helpful. I was pleased to learn that despite the criticism of homework that high school teachers often hear, high school students are capable of articulately communicating the value of homework assignments and realizing that we are not assigning homework to “ruin lives.”

This project inspired me to continue my pursuit of homework assignments that accomplish several goals, including engaging students with a variety of learning styles, reinforcing and providing access to new content, encouraging students to become
scientifically literate individuals, and inspiring students to think creatively. It was rewarding to find out that students appreciate the assignments that I design, as they often take more time to plan and grade, but the variety keeps me more engaged as the teacher and more awake when grading a stack of the same homework assignments.

Most importantly, this project reminded me to continue to prioritize and value open communication with my students. When students are negative about a particular assignment or activity, I need to check in and see what they have to say; they often have valuable feedback to communicate, but the arena of speaking in front of their peers can lead to negative comments. For example, in the past seven years that I have taught high school biology, students have openly communicated that textbook-based assignments can be boring, and they would like to have less of them. Yet, during my project, students consistently explained the value of these assignments and an appreciation for having a mix of assignments, including textbook ones. The students clearly felt empowered when I asked for their feedback. It is important for high school students to learn how to deliver constructive feedback when they are striving to influence change, and I believe my project helped them to see how poorly delivered, vague feedback is not as helpful as well thought-out feedback.

The students were impressively engaged in and cooperative during my project. When I did not provide occasional updates regarding the project, students would ask about how it was going. They appreciated that I was a student too, and that I had my own homework to complete (in addition to grading); I tried to reinforce that teachers should always be learning alongside their students. I am constantly amazed by how many commitments the students manage to juggle, some better than others, and it was helpful
for me to add the deadlines of this project to my list of commitments, so I was also reminded of how difficult time management can be.

Finally, another way that this project informed my teaching is that I will conduct more action research in my classroom in the future, as it is rewarding to have such an open dialog with my students. I would be remiss to ignore that it was particularly invigorating to see that my approach to assigning homework appears to be working well, but I look forward to continued experimentation in the future. I sincerely enjoy reflecting upon what I am doing in the classroom and questioning how I can do it better, as this constant cycle of evaluation and implementation of changes inspires me to try new activities and techniques to create optimal learning opportunities.
REFERENCES CITED


APPENDIX A

PRELIMINARY HOMEWORK INTERVIEW
Appendix A
Preliminary Homework Interview

Reminder to be read to students:
Please remember that participation in this research is voluntary. Participation or non-participation will not affect your grades or class standing in any way.

1. Do you like to study science? Explain why or why not.
2. Do you look forward to biology class? Explain why or why not.
3. Do you like to study biology more or less than other areas of science that you have studied in the past? Explain your response.
4. What two words come to mind when you think about biology homework?
5a. Describe two of your favorite biology homework assignments from the year.
   b. Why did you like these assignments?
   c. Did these assignments help you prepare for the chapter assessments? Explain your response.
6. If you could design a homework assignment for the most recent unit on Photosynthesis, what would the assignment be and why?
7. Do you prefer homework assignments that use the textbook or assignments that do not use the textbook? Explain your response.
8a. How often do you complete your biology homework? Be specific.
   b. If you do not complete the assignments nightly, what is your most common reason for not doing them?
9. Do you look forward to completing your biology homework? Why or why not?
10. On average, how much time do you spend on biology homework each night?
11a. On a scale of 1-10 (with 10 being the hardest), how difficult is biology homework?
   b. Would you like the homework to be more or less difficult? Explain your response.
12. What biology concepts do you remember best from the course so far?
13. Did any homework assignments help you learn those concepts? If so, which ones?
14. What elements, if any, do you find frustrating about biology homework assignments?
15. What two adjectives would you use to describe the type of student that you are?
16. How would you describe the type of learner that you are?
17. What types of assignments generally help you learn new material best?
18. Is there anything else you would like me to know?
APPENDIX B

CELLULAR RESPIRATION PRETEST AND POSTTEST
Appendix B
Cellular Respiration Pretest and Posttest

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

1. All eukaryotic organisms (organisms whose cells have nuclei) carry out cellular respiration.

   TRUE or FALSE

2. Circle the images below of the organisms that perform cellular respiration.

   Coyote  Cottonwood Tree  Owl  Andromeda (plant)

3. Plants perform photosynthesis instead of cellular respiration.

   TRUE or FALSE

4. Cellular Respiration harvests energy from glucose and other energy-rich carbon-based molecules to make ATP.

   TRUE or FALSE

5. Organisms use cellular respiration to bring in respiratory gases and perform gas exchange.

   TRUE or FALSE
APPENDIX C

CHAPTER HOMEWORK SURVEY
Appendix C
Chapter Homework Survey

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

Assignment #1:_________________________________________________________

1. This assignment furthered my understanding of the material.
   Strongly Disagree  Disagree  Undecided  Agree  Strongly Agree
2. This assignment was fun.
   Strongly Disagree  Disagree  Undecided  Agree  Strongly Agree
3. I hope we do more assignments like this one.
   Strongly Disagree  Disagree  Undecided  Agree  Strongly Agree
4. Additional comments about this assignment?

   [ ] Check this box if you DID NOT complete this assignment.
   **Reason for not completing assignment:

Assignment #2:_________________________________________________________

1. This assignment furthered my understanding of the material.
   Strongly Disagree  Disagree  Undecided  Agree  Strongly Agree
2. This assignment was fun.
   Strongly Disagree  Disagree  Undecided  Agree  Strongly Agree
3. I hope we do more assignments like this one.
   Strongly Disagree  Disagree  Undecided  Agree  Strongly Agree
4. Additional comments about this assignment?

   [ ] Check this box if you DID NOT complete this assignment.
   **Reason for not completing assignment:
APPENDIX D

CHAPTER JOURNAL PROMPTS
Appendix D
Chapter Journal Prompts

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

Chapter # (insert appropriate chapter here):
1. Which homework assignments, if any, helped you develop your understanding of the material in this chapter? Please be as specific as you can be.

2. Which homework assignments, if any, increased your interest in the material in this chapter? Please be as specific as you can be.

3. Do you think you could have learned this material as successfully if you had not been asked to complete homework assignments? Why or why not?

4. Please describe any other class activities or moments (not homework assignments) that you think played a role in you learning the material in this chapter.
APPENDIX E

TREATMENT JOURNAL
Appendix E
Treatment Journal

Chapter # (Insert appropriate # here)
Homework Assignment #1: ________________________________________________

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Homework Assignment #2: ________________________________________________

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APPENDIX F

THREE EXAMPLES OF STUDENT WORK
Appendix F
Three Examples of Student Work

1. Poem for Multiple Intelligences Assignment for Cell Respiration and Fermentation

Chapter:

Ode to Cell Respiration

Oh cell respiration, without you
The world would be blue
We wouldn't get energy
Or produce CO2

And golly gee!
What if you didn't give us
Energy?

Life would be rather ick
If we didn't have oxygen for all things aerobic
We would be rather sick
If we were all anaerobic

Glycolysis
Is a thing of bliss
Pyruvic acid from glucose
Without it we'd all be morose

And it produces NADH and ATP
The fabulous carriers of energy!

What comes next is very likeable,
It is the Krebs cycle!
It breaks pyruvic acid
Into CO2
And all we can say is
Thank you,

Next comes the Electron Transport Chain
We all feel joy when we hear that name.
It gives us glee
That it produces 36 ATP!

But what about the where?
If we didn't know we might tear out our hair!

The Cytoplasm
Surrounds and suspends organelles
A task worthy of serenading bells.
What's more it's where glycolysis takes place.

Which makes it a true ace.

The Mitochondria is also quite fun,
It provides the cell with energy
And is where the Krebs Cycle and Electron Transport Chain are done.

And then another splendid creation
Some call it...
Fermentation!
It turns pyruvic acid into waste
A natural garbage sensation.

Now this brief description of cell respiration is done
We see that it
Really is quite fun.
Appendix F
Three Examples of Student Work

2. Geneticist Facebook Page:
3. Create-A-Critter:

**Ursus Cornutus**

*The Armed Bear*

*Location: Tundra.*

With two layers of thick, long hair, it is able to withstand extreme cold, frost, and provides insulation.

As a herbivore, it is difficult for this species to find food during the winter. It migrates in packs of 3-5 to higher altitudes where fierce winds blow the snow off the ground and vegetation is abundant.

During the winter, it lays between clusters of rocks or snow mounds, to protect itself from the cold.

Its claws and horns are used to fend off those who threaten their young, such as the polar bear.

Its feet are of immense size and covered in its long hair. Its bone size is extremely large due to its weight.

Its fur is white while its skin is black. It absorbs heat from the sun with its skin, while its fur helps it blend in with its surroundings.