

THE EFFECTS OF FORMATIVE FEEDBACK ON STUDENT LEARNING IN
SCIENCE EDUCATION

by

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A professional paper submitted in partial fulfillment
of the requirements for the degree

of

Master of Science

in

Science Education

MONTANA STATE UNIVERSITY
Bozeman, Montana

July 2019

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ABSTRACT

Educators always strive to modify their instructional strategies in the hopes to improve student critical thinking skills and discover better teaching practices. As a teacher, one aspect that I have focused on is the feedback that students are provided on formative assessments. Current research indicates that students benefit from prompt, detailed feedback to improve their learning.

For my action research, I investigated the effects of different feedback methods on formative assessments in a high school biology course. The purpose of this study was to identify the relationship between these different formative feedback models and the resulting summative assessment scores. This research also evaluated how these different methods impacted student engagement, student motivation, and efficiency for teachers.

During three consecutive units of study, different methods of written feedback were administered to students on formative assessments. During the initial, baseline unit students were provided with simple, teacher-generated evaluative feedback. This include standard grading practices with answers being marked correct and a score. The first treatment method provided students with teacher-generated descriptive feedback. This feedback included comments or questions to elicit students to think and reflect on their answer. During the second treatment unit, students created their own, descriptive feedback. While a formative quiz was reviewed during class, students used a separate color pen to write their specific notes and details to self-assess and advance their learning. The data from summative scores for each unit was then analyzed and compared to identify relative student growth. Student surveys and interviews were conducted to gain additional perspectives on the topic.

The results of this study qualitatively supports that students' benefit from detailed feedback to redirect their learning and address misconceptions. These comments can be teacher or student generated. It appears to be best practice employ a variety of feedback methods to increase student engagement in the feedback process. When students create their own feedback, it decreases the amount of time needed to return an assessment and saves the teacher countless hours of grading. This research has led to enriched educational practices and student learning in my classroom.

INTRODUCTION

School Demographics

This study was conducted at Naperville Central High School in Naperville, Illinois. The city of Naperville is located about forty-five minutes outside of Chicago and is home to around 145,000 residents. According to United States Census Bureau, Naperville is often considered a wealthy suburb of Chicago with a median household income: \$114,014 and an average housing value of \$398,500 (2018). According to the National Council for Home Safety and Security, Naperville is one of the best cities to raise children and places a high value on education (2018).

Naperville Central is devoted to advancing the learning of about 2,800 students. This school has been given the designation of an exemplary school by the Illinois School Board of Education. This places NCHS in the top ten percent of schools statewide, with no underperforming student groups. This commitment to excellence can also be evidenced by the low student to faculty ratio of twenty two, extensive curricular offerings, and 97% graduation rate.

The demographics of the student population at the time of the study were: 67.1% White, 4.9% Black, 7.9% Hispanic, 15.8% Asian, 0.2% Pacific islander, 0.1% American Indian, and 3.9% two or more races. Although the surrounding area to the high school is considered to be affluent, the high school has about 14% of students who are considered low income. This was indicated by the number of students receiving free or reduced lunch. Within the classroom, 11% of the students are considered to have either learning

or physical disabilities. This includes any students that has an Individualized Education Plan (I.E.P) and received services through the special education department.

Background

When the term assessment is used in everyday language, a picture of students completing lengthy end of unit tests is often imagined. Students receive a score based on the mastery they have demonstrated and the course progresses to the next content area. These summative assessments of learning are only part of the assessment process that occurs within classrooms. The formative assessments for learning leading up to these summative assessments is an area of ongoing research in education today. The purpose of these formative assessments is to help students identify where they are in the learning process and help teachers modify their instruction to help students reach the intended outcomes.

As an educator this is something that I continually strive to enhance. I have tried using different platforms, increasing the frequency, decreasing the turnaround time, along with numerous other ideas to improve formative assessments. Another method I have been using to increase the effectiveness of formative assessments is by including more detailed feedback on assessments. When learning something new, the feedback students are provided with helps to shape their understanding. Reflecting on this concept when students complete an assessment, feedback should be specific to the individual student's learning and elicit students to think about their answers. This is a change from the traditional evaluative feedback that simply confirms the correct answer or incorrect answer with a check mark or slash.

An observation that I have made as a classroom teacher is that some students do not make the connection between their learning and the feedback provided. It appears that students are more concerned about the grade they receive and only quickly glance over the descriptive feedback provided by the teacher. While some students may be motivated to modify their learning based on the feedback, it appears that many are disinterested in using the comments causing them to hold onto certain misconceptions through the next assessment. This is a pattern that many of my colleagues have also observed.

One method I have been using to increase student engagement in the feedback process involves students generating their own feedback while formative assessments are reviewed in class. As a formative quiz is reviewed, students complete detailed notes using a red pen to create their own comments, feedback, and additional notes directly on the formative quiz. This provides students with a way to self-assess and identify where they are in the learning process. This immediate feedback is not only beneficial for advancing student learning, but also supports teachers and administration in quickly identifying students who may benefit from additional support. This could potentially reduce the number of students struggling to learn the content. After utilizing these different feedback methods in my classroom, I began to wonder which of these methods truly has the greatest impact on student learning and grades. As science often does, I wanted to see if there was data to support my ideas.

Research Questions:

The purpose of this Action Research is to determine how these different models of feedback on formative assessments impact student growth. The main research question

for this study is, “How does the feedback method for formative assessments impact students’ high school biology summative assessment scores?” There are three subquestions that will also be incorporated in my research of the main research question:

1. How do different feedback methods on formative assessments impact student engagement?
2. How do different feedback methods on formative assessments impact student motivation?
3. What methods of creating detailed feedback on formative assessments are most time effective for teachers?

CONCEPTUAL FRAMEWORK

Prior to completing any research, an examination of current literature in this subject area was needed. The research databases Academic Search Complete and Google Scholar were used to find such articles. For research studies providing direction, articles were gathered on teacher feedback. Comparable research methodologies were searched to provide potential data collection and analysis methods for an action research project. The purpose of research is to discover what information is already known about this subject area and provide a direction for a future study.

Educational Theory

There are numerous theories about how students learn within a classroom. One idea is that each student has a unique understanding of the world around them based on their experiences. As they learn, they build upon their previous knowledge to modify

their understanding of the content and discredit their prior misconceptions. This constructivist viewpoint corresponds to student feedback in many ways.

Alan Colburn explains constructivism as a way to help change student beliefs. “Teaching is about helping students understand how and why scientifically accepted explanations explain and predict what will happen in a given situation better than their intuitive ideas (Colburn, 2000, p.10). To do this effectively, three criteria must be accomplished. The student must first have a clear understanding of their own ideas. The student must then understand the problems with their own ideas. Finally, the student must be presented with alternative ideas that work for them specifically.

This coincides with my ideas for student feedback in numerous ways. On an assessment, students present their own understanding of the information based on their response to a given question. When feedback is provided for the student, it informs the student of the misconstructions in their previous ideas. This is essential for the construction of new knowledge. The final step, which is the most challenging, is to provide students meaningful information to guide them to a correct understanding that works with their previous experiences. One of my goals for this project was to see how this type of feedback could improve a student’s learning.

Christiane Herr describes constructivism learning as, “ongoing conversation held between the learner and the world she/he is trying to make sense of” (Herr, 2014 p. 396). Herr describes numerous methods of providing feedback to students that coincide with constructivist theory to keep those conversations going. In a study including college

architecture students ($N=200$), Herr looked at providing feedback utilizing two different methods throughout the learning process.

The method that was used early in the learning process was provided by the teachers. Throughout the semester, during drawing-based exercise, feedback was provided through rough grading categories and detailed discussions about the students work in front of the class. This idea was based on the assumption that students would prefer this method of feedback compared to detailed feedback only being provided by the teacher at the end of the semester. During these conversations, students were allowed to take notes, complete checklists, and ask questions to further develop their understanding.

Later in the learning process, during design projects, students had the opportunity to receive feedback from their intended users of their product. For this scenario, students were asked to design cardboard structures for children. The children were then allowed to explore and use the projects in any manner that they choose. This revealed a wealth of information for the architecture students that was meaningful to their specific project. The feedback provided students with an experience about their potential strengths and weaknesses to their designs, rather than just being instructed on these concepts.

This article helped provide different approaches to feedback throughout the learning process. During the early stages, students may need feedback from the teachers. This could be because of their lack of experience with the content that leads to misconceptions. Later in the learning process, students could generate their own feedback. This would provide students the opportunity to reflect on their responses and

generate specific feedback that is meaningful to where they currently are in the learning process. For my action research, both methods were utilized.

Teacher Feedback

The purpose of teacher feedback is to identify a student's knowledge and alter their learning process. Feedback provided on a summative assessment is too late to successfully accomplish this task. Descriptive feedback on formative assessments however can be used to further modify instruction and further a student's learning.

The first article I found on formative feedback was short, but described many attributes of teacher feedback that I would deem to be necessary. Jarene Fluckiger, Yvonne Tixier y Vigil, Rebecca Pasco, and Kathy Danielson describe their view on providing formative feedback and the influence on student growth and motivation (2009). The article also describes several methods of providing feedback more frequently and effectively. All of these strategies incorporate students as partners in providing feedback. The purpose of this is to focus on the learning rather than the grading. In my own teaching philosophy, this is a fundamental component of formative assessment. The strategies in the article, "help us to improve our teaching, to help students adjust their own learning tactics, and to develop a class climate focused more on learning than on grading" (Fluckiger et al., 2009, p.137).

The strategy that I was most intrigued by was referred to as the three color quiz. With this approach, students collaboratively complete a formative quiz in three colors of ink. First, a student will write out their answers using black ink for what they personally know. Then, working collaboratively with groups of four or five students, students will

use green ink is for questions that are left unanswered or for responses that need to be revised. Finally, students use a pen with blue ink to enhance their answers with information that was collected from the textbook or class notes. By completing this activity, students can identify area of strengths and weaknesses prior to completing an end of unit exam.

Although the actual data from the three-color quiz was not presented, survey data from forty three graduate students revealed an increase in student learning. The Likert survey results indicated that a majority of students had a greater understanding of the material and had a more meaningful learning experience compared to a traditional quiz. The data also revealed that after completing this formative assessment, most students (84%) choose to look up the information they did not know. This indicates students monitoring their own progress towards mastery which is a great skill to develop at any level.

Another approach that is discussed is the use of digital blogs to provide groups of students with feedback. One of the issues with providing feedback to students is the time required by the educator. In order to save time, teachers often default to insincere feedback such as “need work”, “math error” etc. By using a collaborative blog, students can ask questions about their work and a teacher could provide comprehensive feedback for that student and their peers to view. This inclusive practice provides all students with benefit from the feedback to self- assess their own work.

This article helped me understand the importance of incorporating students into the assessment process. When students play an active role in the assessment process, it

creates a culture for learning that focuses on learning and encourages students to grow from their mistakes. Although some of the methodologies discussed do not correspond with my action research project, I can foresee using similar strategies in my own classroom in the future. After reading this article, my goal was to find an article with more background information on all types of formative feedback.

A research report by Valerie J. Shute provides a comprehensive description providing detailed feedback on formative assessments (Shute, 2007). The author defines formative feedback as, “information communicated to the learner that is intended to modify the learner’s thinking or behavior for the purpose of improving learning” (Shute, 2007, p. 1). This feedback needs to be specific and not be hindered by scores or grades. There are two key traits to formative feedback: verification and elaboration. Verification confirms if the answer is correct. Elaboration prompts students towards the correct answer.

The author presents several findings pertaining to the length of the feedback and the timeframe for when it should be given. In general, studies show that elaborative feedback compared to feedback containing less information tends to increase student learning. Feedback such as “great” or “error” provided no explanation or direction for a student’s learning. However, once the feedback becomes too long or complicated, the message becomes diluted and learners lose concentration.

The article details numerous types of feedbacks ranging in complexity. In my own classroom, I tend to use “error-flagging” when providing quick feedback. This identifies the location of an incorrect response, but does not give the correct answer. As answers

are then discussed, students are encouraged to write in their own comprehensive feedback. When providing more elaborate feedback I tend to use “hints/cues/prompts”. With this method, feedback guides the student in the right direction but does not give the correct answer. Often, I try to identify misconceptions and ask students further questions to reflect on their answers.

The author presents conflicting results for the timing of feedback. With immediate feedback, learners are provided with helpful information to correct their misconceptions. Evidence supports that this helps with retention. However when corrective information is delayed, there is a delayed-retention effect. “This asserts that initial errors do not compete with to-be-learned correct responses if corrective information is delayed. This is because errors are likely to be forgotten and thus cannot interfere with retention” (Shute, 2007, p.15). This seems to conflict with the viewpoints discussed in numerous education classes and what is considered best practice by current school administrators.

This research report provided a detailed background on the research that has already been completed in the area of formative feedback. After reading, I evaluated my own methods that I currently use in my classroom. For my action research project, I incorporated concise, elaborate feedback within a small time frame. Based on the first article, involving students in this process can help decrease this time frame while engaging students with the feedback.

Purpose of Formative Assessments

The characteristics of the feedback provided to students appears to have a profound effect on their learning process. This led me to further research in the area of formative assessments. What is the overall objective for formative assessments?

The literature review by Paul Black and Dylan William provides a detailed analysis of theoretical and practical issues associated with formative assessment (1998). The authors interpret formative assessment as “all those activities undertaken by teachers, and/or by their students, which provide information to be used as feedback to modify the teaching and learning activities in which they are engaged” (Black & William, 1998, p.7). Formative assessment is not only useful for improving student scores on summative assessments, but also improving the teachings within the classroom. Improving students’ scores on summative assessments is one of the focal points to my future action research project.

The authors list numerous studies that provide evidence for the use of formative assessment in the classroom. Many of the studies found that frequent assessments led to increased scores on exams. The study that I was most interested in pertained to an inquiry-based middle school science curriculum. During a conceptual unit on force and motion, the experimental group ($N=180$) received structured discussion to encourage reflective assessment. When comparing project and test scores the experiment group showed a significant overall gain when compared to the control group ($N=180$).

As a teacher in a co-taught class, what I was intrigued by was the effect on students who scored “low” on the pre-test. With the treatment method, those students

showed the greatest growth between their pre-test and post-test scores. This indicates the importance of formative assessment for learners who are struggling and the improvement of learning.

Similar to other discussed studies, Black and William review several other studies that indicate that students must play in active role in order for formative assessments to be considered productive. Through the analysis of these articles, the authors break the student's role into two critical parts. The student must first understand that there is a gap between their current understanding and the desired outcome. The second is that students must take action to close this gap and reach the desired outcome.

In my own teaching practice, I scaffold assessments to allow students to identify where they are compared in relation to the standard that is being addressed. At the start of each class period, a target is reviewed for the day's activities. On most days I try to review this at the end of the class period as a way for students to monitor their progress. I believe students struggle to understanding how to best close the gap when they are not making such targets. Many students lose motivation after a low performance on a formative assessment and assume that they will continue to struggle on future assessments. When the grade is removed from the formative assessment, I believe this could help alleviate this issue. This research supports my idea for removing the grade for formative assessments during my action research (Black & William, 1998).

What also seems to be a key factor is the feedback that is provided to students. This coincides with the research about the feedback methods previously discussed. The article concludes that frequent diagnostic feedback must be made by the teacher and that

students must be given the opportunity to discuss with peers how to remedy their errors. This opportunity for discussion is a strategy that I have recently attempted and found success with in my own classroom.

From all of the studies discussed in Black and William's literature review, formative assessment is widely used to monitor student progress and provide feedback to improve student learning. This is an integral part of my own pedagogy. As part of my action research project, formative assessment was used as a foundation for providing students feedback in the hopes of improving their understanding of the content.

Research Methodologies

An article by Josh McCarthy provides a similar research approach to my intended method (McCarthy, 2017). The author views feedback as the core component for enhancing students' performance. Therefore the purpose of the study was to compare three different feedback methods. The techniques included staff to student feedback in class, peer to peer feedback in class, and peer to peer feedback online. "Peer feedback is a process in which students provide comments and critiques on their peers' submissions" (McCarthy, 2017, p.128). Since students are being provided with feedback from numerous peers, this creates a wide range of feedback sources. Since students are looking at the work of their peers, naturally they are going to compare their own work as a form of self-regulation of their own learning.

The feedback methods were trialed with 118 students enrolled in a post-secondary media arts course. Every other week students were required to submit their in progress work to an online platform and offer critiques on their peers' submissions. Feedback was

to be constructive in nature and address areas of strengths and weaknesses of the projects. During the weeks that students did not submit their work online, students brought in their current work and discussed their work with peers and staff. Both of these feedback methods were timed in such a way that students were able to make corrections to their work prior to submitting their completed projects. At the end of the semester, students completed a survey about the different feedback models. Students were asked about the effectiveness, format, and quality of the feedback models. The format of the survey included both Likert-type scale statements and open-ended questions.

The results of the study indicated that a majority of students preferred receiving feedback from a wide range of sources. Although students did find peer feedback to be beneficial, teacher feedback was still preferred by most students. I would interpret this as students viewing the teacher as the expert in the subject area. It was also noted that face-to-face feedback tended to be less critical than the feedback provided digitally. I believe this is because people in general tend to be more cordial in person. Students also indicated that evaluating their peers work caused them to reflect on their own work.

In my own case study, I studied the impact of different formative feedback methods on summative assessments. McCarthy used a comprehensive student survey that allowed for him to clearly present his findings. I found his survey to be very beneficial and provide guidance for my own action research project. In the survey however the author did not question students about how they used the feedback that was provided. I believe this would strengthen the conclusions of his paper and is included my project.

There are numerous ways that students can utilize feedback to modify their learning experience. One idea from Karen Handley and Lindsay Williams is to use sample projects with annotated feedback prior to students submitting their final assignments (Handley & Williams, 2011). The problem that the authors discuss is that many students perceive their feedback as meaningless to future assignments. This could be due to the fact that they do not understand the meaning of the feedback or how it applies to the assessment criteria. I have noticed a similar issue in my own classes when students do not understand written feedback that I have provided them and ask questions such as, “What does this mean?” or follow up questions asking to further explain the comment.

The authors propose that students must be engaged in order for formative feedback to be considered effective. When students are not engaged with the feedback, there is no link for future assessments and therefore cannot use the feedback to close the achievement gap. To engage students in feedback, prior to submitting their final assignments, example assignments were posted to an online discussion board. Students could view exemplars and post comments or questions to tutors and peers on a discussion board (Handley & Williams, 2011). These exemplars are not rubrics of the standards being addresses, but rather models demonstrating an understanding of the standards.

The authors used exemplars in fourteen classes of twenty to twenty-eight undergraduate students enrolled in a business inquiry course. The course focuses on the development of research design and data collection. The exemplars used in this study were collected from previous students of the course. The samples were similar in the

structure to the assignment students were given, but focused on a different topic area. All assignments were annotated with feedback and uploaded to the course webpage. Students were instructed that the exemplars were available three weeks prior to their assignment due date and could be used to help with the preparation of their assignment. After the assignment was collected, there was a student questionnaire and informal discussions about how students used the exemplars for their assignments.

Through the analysis of these survey results, it was concluded that students found the use of exemplars to be very beneficial. Data tracking software on the page also revealed that students referred to the exemplars several times prior to the submission of their own work. Students indicated that they liked being able to see a layout of an assignment and viewed the feedback as relevant for the improvement of an assignment.

Although I did not use exemplars in my action research project, I have found the sample assignments in this course to be very beneficial when writing my own assignments. The article contained excellent data collection and several additional survey questions that I modeled from in my own action research project. I did however note that only fifteen percent of the class responded to the survey. To increase the validity of the results, I attempted to have a higher percentage of students respond to the questionnaire. There was also no “control” group to compare quantitative data with. This creates an additional question for the reader. How much did students improve compared to when there was no exemplars? In my project, I included such a group to eliminate this question.

Student Motivation

One area of education where all teachers try to improve is student motivation. Teachers want create a culture of learning within the classroom that makes students want to learn. Formative assessments and the feedback from them can help motivate students to improve their leaning by providing the reasonable steps necessary to do so.

Kathleen Cauley and James McMillian discuss methods that teachers can use to gain information about student understanding, provide feedback, and empower students to set and achieve learning goals (2010). The authors view formative assessment as the most powerful way to increase student motivation and achievement.

The article provides numerous characteristics and examples of low-level and high-level formative assessment. The characteristics of low-level formative include: structure, delayed feedback, no self-evaluation, a passive role by learners. With this type of assessment the motivation is extrinsic and is based on passing the assessment. High-level formative involves both students and teachers during instruction and helps direct instructional tasks with immediate feedback. This causes more intrinsic motivation for the student to improve their learning.

Cauley and McMillian go on to explain five key practices that leads to high level formative assessments to increase student motivation. The first factor is to provide clear learning targets. This provides a foundation for students to understand what exactly they are learning and set goals towards reaching these targets. This corresponds with the second and third factor of providing feedback to students about their progress towards these targets and attribution cues towards their success. Providing students with specific

feedback to help adjust their learning creates a positive expectation and the belief that they can the learning targets are achievable. From my experience when students have the tools to and believe that they can accomplish something, their motivation is often increased.

Effective formative assessment also creates high levels of student self-assessment and facilitates students' goals towards improvement. "Student self-assessment involves much more than simply checking answers; rather, it is a process in which students monitor and evaluate the nature of their thinking to identify strategies that improve understanding" (Cauley & McMillian, 2010, p.4). When students know exactly where they are in their learning, they can follow a learning path to find success.

This article provided me with information and evidence to better utilize formative assessments to increase student motivation. Student motivation and engagement is a subquestion for my action research. I am particularly interested in how different feedback methods effect student motivation. This article provided a background and key factors that help create successful formative assessments that increase motivation and learning within the classroom.

The intrinsic motivation that is associated with formative assessment often stems from its ability to promote the self-regulation of learning. David J. Nicola and Debra Macfarlane-Dick provide a guideline for creating feedback to allow students to manage their own learning (Nicol & Macfarlane-Dick, 2006). The authors describe self-regulating learning as the active monitoring and regulation of a number of different learning

processes. This includes setting learning goals, utilizing learning strategies to achieve goals, managing learning resources and reacting to teacher feedback.

The authors define good feedback as anything that “might strengthen the students” capacity to self-regulate their own performance” (Nicol & Macfarlane-Dick, 2006, p.8). Through the analysis of research literature, the authors then developed a fundamental list of qualities of good feedback practice. These qualities include: clarifying good performance, promoting self-assessment, high quality information, encourages teacher-student dialogue, promotes motivation, provides opportunities to close the learning gap, and provide the teacher with the necessary information to modify their instruction (Nicol & Macfarlane-Dick, 2006). The authors provide a detailed rationale and strong contextual evidence for each of these principles.

The findings of this article help identify the fundamental standards of feedback that help establish a culture for learning that fosters self-regulation. Self-regulated learners are often intrinsically motivated. As a subquestion to my research, does increased student motivation increase performance on assessment? Reflecting on my own teaching practices, this is one area where I believe I struggle. As an educator it can be very time consuming and tedious to provide feedback to each student that allows students to self-correct their own performance. This article delivers guidelines to easily organize feedback to support and motivate students. These principles were therefore incorporated into my research project.

METHODOLOGY

Numerous classroom observations and courses in the MSSE program helped to form the treatment and data collection methods conducted during this research. These methods were intended to answer the main research question of how different feedback methods impact student growth, as well as the subquestions relating to student engagement, student motivation, and timeliness for educators. During the study, my teacher course load included five sections of biology. Three of these sections were co-taught with a special education teacher.

Biology at Naperville Central High School in Illinois is an inquiry-based laboratory course aligned with the Next Generation Science Standards that investigates the interconnections of life. In these courses, formative assignments account for five percent of the gradebook. This includes activities such as small quizzes, in-class activities, and homework checks for learning. In this research, I focused on the feedback provided during these formative quizzes. The other ninety-five percent of a student's grade comes from summative assessment scores. This includes larger quizzes, projects, and tests of learning. These assessments were used to demonstrate student growth and learning for a unit of study.

Demographics

Although I implemented the same treatment for all of my classes, I collected data on two of the sections. During the Fall semester of 2018, I selected my second hour class and my sixth hour class. These class periods remained the same, with a few schedule changes second semester. The demographics to these sections are included in Table 1 and

Table 2. This research project was exempt from a full IRB review due to the low amount of risk to subjects and data will be reported without identifiers (Appendix A).

Table 1
Semester One Classroom Demographics

Class Period	Total Students (<i>N</i>)	Students are Males (<i>N</i>)	Students are Females (<i>N</i>)	Students with 504 (<i>N</i>)	Students with IEP (<i>N</i>)	Low-Income (<i>N</i>)
Second	22	10	12	0	7	3
Sixth	23	8	15	3	0	1

Table 2
Semester Two Classroom Demographics

Class Period	Total Students (<i>N</i>)	Students are Males (<i>N</i>)	Students are Females (<i>N</i>)	Students with 504 (<i>N</i>)	Students with IEP (<i>N</i>)	Low-Income (<i>N</i>)
Second	20	8	12	0	6	2
Sixth	23	8	15	3	2	1

My second hour section both semesters was co-taught with a special education teacher due to the accommodations and needs of numerous students. Biology is a predominately sophomore class, with only one junior in the class first semester. This junior was identified as a struggling learner who took a lower level course that focused on the fundamentals of chemistry the year prior. This class struggled with motivation and improving scores between formative and summative assessments. Prior to this research, on previous assessments, about 23% of students did not demonstrate mastery with a score less than 70% on the final summative assessment of the unit. This attribute, along with the diversity of the learners in this course, provided a spectrum of responses for assessment scores and surveys.

My sixth hour section was not co-taught and consisted of all sophomores. This class was more vocal by comparison to second hour and tended to be more engaged in the

material. Prior to this research, on previous assessments, usually less than five percent of students score under a 70%. However after the first units, many students struggled to utilize the feedback provided on formative assessments. The results of this class helped to provide data for how this habit changed over the duration of the semester.

Treatment

The research for this project was conducted over three consecutive units of study. Each of these units lasted for approximately three to four weeks. A detailed timeline is provided in Table 3.

Table 3
Treatment Timeline

Curriculum Unit	Topic	Dates	Treatment	Data to be Collected
Two	Energy	9/17- 10/24	None	<ul style="list-style-type: none"> • Pre-Survey • Application: Request for Exemption
Three	DNA/ Protein Synthesis	10/25- 11/20	Evaluative Feedback	<ul style="list-style-type: none"> • Formative Scores • Summative Scores • Student Data Checks
Four	Cell Cycle	11/27- 12/14	Descriptive feedback (Teacher Generated)	<ul style="list-style-type: none"> • Formative Scores • Summative Scores • Student Data Checks
Five	Meiosis	1/8- 2/1	Descriptive feedback (Student Generated)	<ul style="list-style-type: none"> • Formative Scores • Summative Scores • Student Survey • Student Interviews

Prior to the treatment, students completed a survey on how they currently used feedback. The purpose of this survey was to understand how students currently were using feedback and what components of feedback they found to be the most beneficial.

The first unit for this study focused on DNA and protein synthesis. This served as a baseline unit. In the past, students have done well during this unit. Students completed

formative assessments and summative assessments throughout the unit. On these assessments, students received scores and evaluative teacher feedback. The feedback included methods such as error flagging where answers are simply marked correct or incorrect.

During the unit, students completed a quick data check to see if they are using this feedback and their opinion. To measure student growth, the scores on the formative assessments were compared to those on the summative assessments. Growth was indicated by an improvement between the assessment scores as discussed in the instrument section of this paper.

During the unit pertaining to the cell cycle, only prescriptive teacher feedback was provided to students. In the past, students tended to struggle with some of the more detailed components of this unit. Prescriptive feedback entailed detailed responses to student answers to help facilitate critical thinking or guide their learning. For example, a common misconception for this unit is that the X-shaped replicated chromosomes are homologous chromosome pairs. On a formative quiz, I asked students to define the word “pair” or asked what had already occurred with the cell’s DNA during this point of the cycle. The purpose of these comments would be to engage students in thinking about their answer.

Similar to the previous unit, students completed a quick data check to see if they are using this feedback and their opinion. The growth between the formative scores and final summative assessments was also collected to measure student growth using the same methods as the previous unit.

The final unit of study was the first unit of the Spring 2019 semester. This is why demographics for both semesters were included in the previous section. This unit addressed meiosis and genetics. In years prior to this study, this has been a longer unit where students are very interested in the material. Students have learned about many of the fundamental concepts during middle school, but held many misconceptions and therefore struggled with the application of the content. Students were unfamiliar with Non-Mendelian inheritance patterns and also struggled to connect information about the central dogma of biology to genetics. For this unit, students created their own detailed feedback. The rationale for using this method last is so students could model their feedback based on the comprehensive feedback provided by the teacher during the previous unit.

This occurred when formative quizzes were reviewed during class. Students would complete a formative quiz, and then be asked to flip over their exams when they were finished. Once everyone was done, red pens would be distributed for students to write their own feedback. Students were encouraged to write as much information as needed to help them understand the concept. This included corrections and any additional notes to help them further understand a concept.

For example, students tend to have the misconception that with two rounds of cell division and there needs to be two rounds of DNA replication in meiosis. While reviewing the formative quiz on this concept I asked how if that occurred how would that impact the cells produced from meiosis and what would occur if those cells then

combined to make a new offspring. As class discussion, students added these additional notes on their formative quizzes.

At the end of the treatment, students completed a final survey on the different feedback methods and how they have utilized the feedback for their learning throughout the semester. The results of this survey were compared to the first survey to see if students have altered how they use the feedback provided to prepare for future assessments. The format was similar to the first survey that students had completed using Google forms. Student interviews were also completed to further probe information about the treatment methods and to discover the student perspective on which methods appear to be most beneficial for learning.

Instruments

Throughout this process, I collected data using a variety of instruments. For each question and subquestion, there were at least three different methods of data collection. This helped to triangulate the data and increase the validity of the research. An outline of all the potential tools and methods can be found in Appendix B. The validity of each instrument was peer-reviewed by colleagues and the project advisor.

The central instrument for investigating student growth throughout a unit would come from the analysis of formative and assessment scores. Formative scores would establish a baseline of students' current knowledge. As a classroom teacher, this also helped me to identify misconceptions and modify my classroom instruction.

The variance between these formative scores and the summative scores would quantitatively indicate student growth. Each formative assessment would be recorded throughout the unit, as well as any summative assessments.

To compile and organize this data, I created an Excel spreadsheet. A screenshot of this instrument can be found in Appendix C. The first two columns will have each student's name and ID number. To keep student confidentiality, the name column has been removed. The adjacent columns are where the students' scores from the formative assessments were entered throughout the unit.

Ideally students would show an increase in scores, or growth, throughout each unit. However, since the formative assessments during any one unit may evaluate different standards, there is an additional column for the average formative scores. There has been a formula entered to calculate this average once scores are entered. The next column is where the students' final summative scores were entered.

Once entered, the student growth was measured by calculating their gained score. A student's gained score was calculated by subtracting the "Average Score on Formative Assessment for Unit" from the "Score on Unit Summative Assessment" columns. There has been another formula entered to calculate this gained score once scores have been entered. There is also an additional calculation for measuring the average student growth for the class during the entire unit.

I have also added a conditional formatting to help with progress monitoring of student scores. If a student scores above a 70.0, the box was filled with a light green color. This is an indication that the student is proficient and meeting the standards. If the student scored below a 69.9, the box was then filled with a light red coloring. This is an indication that the student is below proficient and not meeting the standards.

Another crucial instrument for this study was the student surveys. For the surveys, students described their preferences on different feedback methods and consequently how they influence their summative scores.

The first survey provided data for how students used any feedback prior to any treatment. This was conducted after the second unit of study for the semester, prior to providing students with the baseline unit. A full copy of this instrument can be found in Appendix D. This document was converted into a Google Form for student distribution using the Hapara platform.

The first few sections of the survey relate to student background, motivation, and study habits. The fourth section of the survey asks students to select what study resources they use and find most valuable. The reason for these questions was to reveal if students were using formative assessments throughout the unit and if they found value.

The next three sections were designed to expose students' beliefs and preferences about teacher and student generated feedback. Prior to any treatment method, I wanted to understand student opinions about the feedback they have received during the first two units of study in biology.

The last section had students describe and explain the features of feedback they thought were needed and most beneficial. These questions were intended to understand if students were more concerned about the score or comments on the formative assessments as a means to help improve their learning.

After the distribution of the first survey, I made several modifications to help improve the clarity and validity of the post-survey. When looking at student preferences

to student and teacher feedback, a clear pattern did not emerge due to a poor question format. In the second survey, instead of two separate questions, this question was scaled between teacher feedback and student generated feedback to identify a true preference. For ranking questions, more specific instructions were provided so that students could answer the question that provided true data. A full copy of this instrument can be found in Appendix E.

In addition, there was individual student interviews that will allow for a deeper analysis of how students believe the feedback has impacted their summative scores. Throughout this process, I kept notes from my observations and reflections on the different feedback methods. I used this to help address the third subquestion of which method is easiest for teachers. After collecting all of the data from the described instruments, a thorough analysis of the results was completed to identify any patterns. This research design was submitted to the Institutional Review Board at Montana State University, anonymity was utilized, and an IRB exemption was received (Appendix A).

DATA AND ANALYSIS

Prior to treatment, students had been utilizing various forms of feedback. On some formative assessments, I would total points or write comments. On other assessments, students would grade their own assessment during a classroom discussion that reviewed the material. For this reason, a pre-treatment survey was given to see how students were utilizing feedback in general. After students completed the different treatment methods, a second survey was given to see how students' viewpoints may have

changed. This, along with student interviews and data checks, provided qualitative insight to student rationale.

Qualitative data was collected by comparing student formative scores to their summative scores for a particular unit. The difference between a student's average formative score and student's average summative score was used to calculate a student's "growth" for the unit.

Student Growth

For all units, student scores for all assessments were converted into percentages. This allowed for an easier comparison between formative and summative assessments. The average formative scores were then subtracted from the average summative scores to calculate the average student growth. It should be noted that different assessments have different weights in the gradebook (Figure One). For example, formatives account for five percent of a student's grade and summative scores account for the remaining ninety-five percent. Also, quizzes are worth less points than a unit exam. For example, the third unit had one summative test worth one hundred points and two quizzes worth eleven points. The summative assessment test had a much larger impact on the students overall grade.

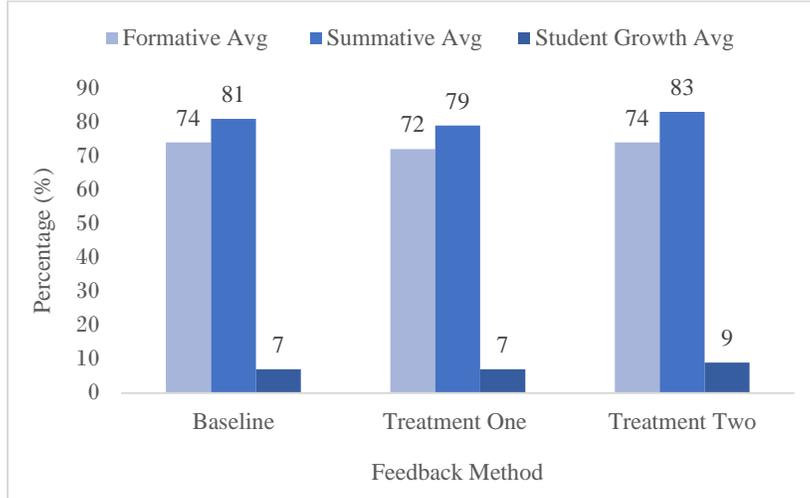


Figure 1. Student growth per treatment method, (Baseline: $N=45$, Treatment One: $N=45$, Treatment Two: $N=43$).

Overall, there was growth between the formative assessments and the summative assessments for all units. This should be expected as material is covered in more depth as the unit progresses and material is continually reviewed in class. I often stress that the formative assessments are used to monitor student learning. They are also an additional resource to help students prepare and improve their learning prior to future summative assessments. One element that should be noted is that the growth shows how much improvement a student made between the formative and summative assessments for the unit. This means that students have already been exposed to the content through labs, activities, and classroom discussion. This does not demonstrate their overall growth, as if compared to a pre-assessment given prior to instruction.

When looking at the overall data, there does not seem to be a significant change between the treatment methods and the baseline unit. The baseline unit and first treatment method, where students were provided either simple or descriptive feedback from the teacher, exhibited seven percent growth. For the second treatment method, where

students created their own feedback, there was an average of nine percent growth. To identify if this difference was significant, a t-test was conducted between the baseline, treatment one, and treatment two groups (Table 4).

Table 4
Results of t-Test between Groups

Groups	p-Value	Degrees of Freedom
Baseline Unit and Treatment One	0.92	43
Baseline Unit and Treatment Two	0.69	43
Treatment One and Treatment Two	0.65	42

Note. (Baseline: $N=44$, Treatment One: $N=44$, Treatment Two: $N=43$).

A t-test between the different groups resulted in values greater than 0.05 for the baseline and treatment groups. From a statistical viewpoint, there does not seem to be a large impact on student growth between formative and summative assessments in relation to the mode of feedback. This pattern of consistent growth could be explained by comparable teaching methods used in the three units that were studied.

When looking at the data for the students that have I.E.Ps, the data was very similar to the overall group. For the baseline unit and first treatment method, students with I.E.Ps demonstrated about thirteen percent growth. These were both higher than the second treatment, where this group of students improved their scores an average nine percent. A t-test was performed, demonstrating values greater than 0.05, indicating no significance between the data sets. One reason could possibly be that students in this group have difficulty deciphering teacher comments and creating their own. Perhaps this group of students benefit from the clear communication of simple formative feedback.

When comparing the final summative test score, the second treatment method also showed the highest average summative score and the highest percentage of students demonstrating mastery.

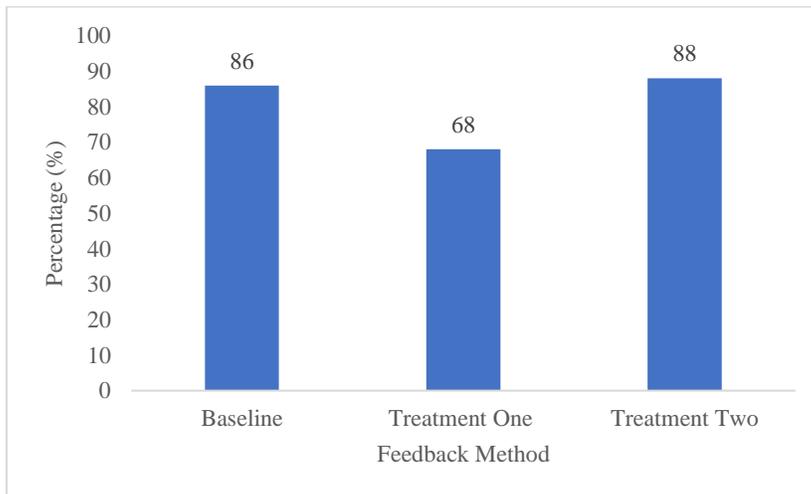


Figure 2. Students who meet expectations, (Baseline: $N=44$, Treatment One: $N= 44$, Treatment Two: $N=43$).

The perimeters for meeting expectations was defined as students who had received a seventy percent or higher on the unit summative. During the baseline unit, eight-six percent of students demonstrated mastery at this level. This dropped significantly for the first treatment method. However if you removed students that were just below expectations (sixty-nine percent), the number increased from sixty-eight percent to seventy-seven percent of students meeting expectations. For the second treatment unit, this number was the highest with eighty-eight percent of students scoring above a seventy-percent. Although slight, this again indicates that the second treatment method may be best for student learning by a slight margin. For all three units, the average student score for those that did not meet expectations was a sixty-three percent. Many of these students struggled with the formatives throughout the unit, and did not

seek out additional help or instruction. This could be related to student motivation for this course. Further analysis between the two classes were completed to see if these patterns were consistent between the two different class periods (Table 5).

Table 5
Rounded Average Scores per Unit

	Baseline Unit Formative	Baseline Unit Summative	Treatment One Formative	Treatment One Summative	Treatment Two Formative	Treatment Two Summative
Period 2	72% (N= 21)	80% (N= 21)	73% (N= 21)	79% (N= 21)	73% (N= 20)	81% (N= 20)
Period 6	74% (N= 23)	81% (N= 23)	72% (N= 23)	79% (N= 23)	76% (N= 23)	85% (N= 23)
Total	73% (N= 44)	80% (N= 44)	73% (N= 44)	79% (N= 44)	75% (N= 43)	83% (N= 43)

Based on Table 5 it appeared that Period Two kept relatively steady formative and summative scores for each unit. For Period Six, the formative scores were all within a close range for the three units of study. However this class showed a five percent increase in their average summative scores during the second treatment unit. There was also only one student that scored less than a seventy percent on the summative test during the second treatment method for this class period. Student interviews and surveys were completed to further analyze the results of the quantitative data.

Student Surveys

Qualitative data was collected from student surveys throughout the research. From the student surveys, there are several patterns of student preferences that emerged. Based on both surveys, it appears that most students do not spend a large amount of time studying outside of class for biology.

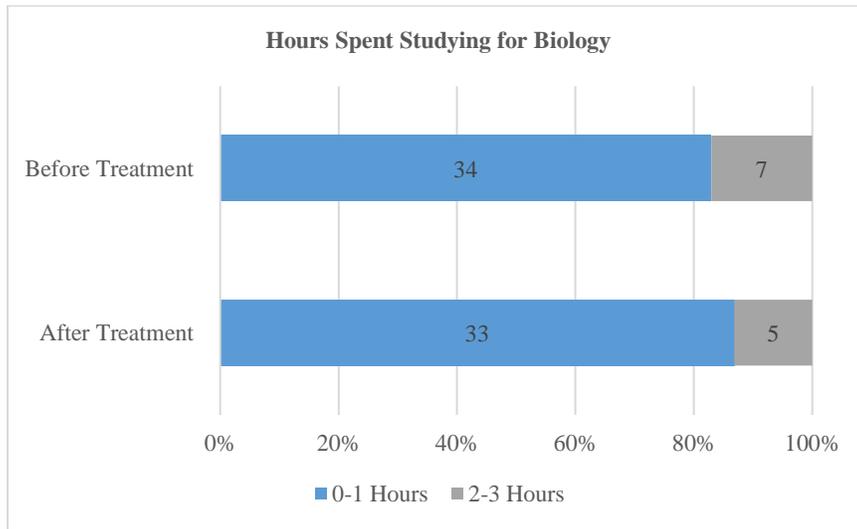


Figure 3. Student responses to hours spent studying for biology, (Before Treatment: $N=41$, After Treatment: $N=38$).

Over eighty percent of students said that they only study for biology for less than one hour per week. With the current student-centered curriculum and use of class time, this was not entirely surprising to me. In class, students spend a majority of time collaborating with their peers, developing models, and presenting their ideas through classroom discussions. Also, formative quizzes are reviewed during class. Sometimes this is a simple classroom discussion. At other times this would involve students discussing with their groups and making a key for the assessment or whiteboarding certain answers for the whole class. Students have the opportunity to revisit material and address misconceptions numerous times in class prior to an assessment. This is particularly true for formative assessments during the second treatment method. This decrease in the amount of time studying outside of class could be related to the additional time spent reviewing formative quizzes during class.

To answer my main research question, I wanted to examine how students were using the feedback provided as well as their perceived value of the feedback before and after treatment. One pattern that I noticed is that more students began to use their formatives to study.

According to Figure 4 prior to treatment only fifty-five percent of students used formative assessments as a tool to study, compared to nearly eighty percent after the treatment methods. This shows that after treatment, more students were using formative quizzes to study.

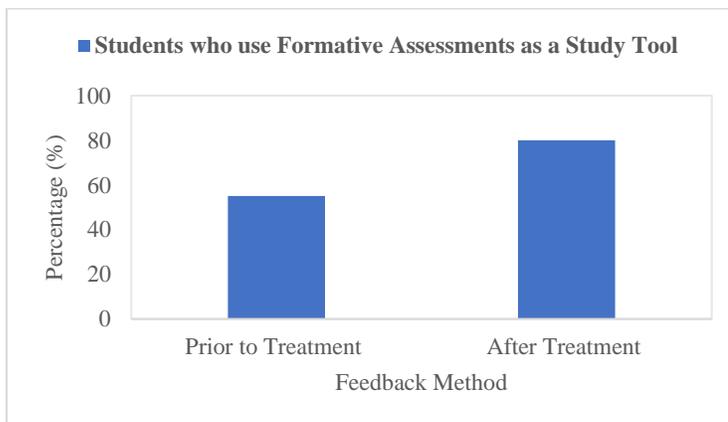


Figure 4. Formative assessments as a study tool, (Before Treatment: $N=41$, After Treatment: $N=38$).

To confirm this data, there was a follow up question that in both surveys that asked students to rank different study resources. This data, found in Figure 5 seems to contradict the data found in Figure 4.

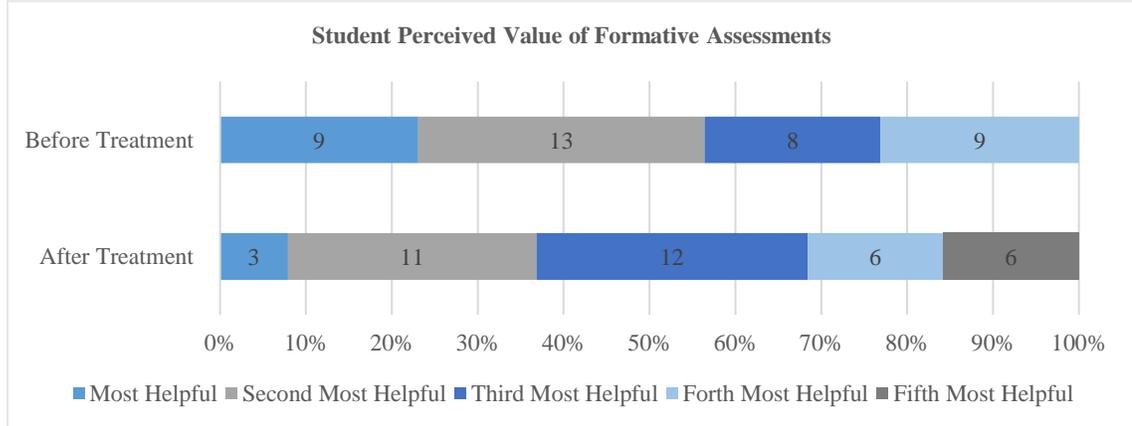


Figure 5. Student perceived value of formative assessments prior to treatment, (Before Treatment: $N= 41$, After Treatment: $N=38$).

Prior to treatment, twenty percent of students found formative assessments to be the most helpful in preparing for summative assessments. However after treatment, only about seven percent of students found formative quizzes to be the most helpful.

This was surprising because in class my co-teacher, and I often stress how formative assessments can be used as a tool to help prepare them for future summative assessments and similar small versions of summative assessment style questions.

I believe this could be due to the fact that students were thinking of just evaluative teacher feedback and not when detailed feedback was provided or generated. Another possible issue was students misreading the question. The first time the survey was distributed to students, I thought the ranking questions had clear instructions. However, based on evaluating individual student answers, some students did not rank each item but instead gave a scaled answer for each option (Figure 6).

Consider the major resources available to you during the first two units of biology. Select 1 for the most helpful and 2 for the next most helpful and so on. *

	1	2	3	4
Daily Class Slides/Notes	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Lab Notebook	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Formative Assessments	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
Unit Study Guide	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>

Figure 6. Student response to survey rank question.

Another issue that a student in my sixth hour class told me that she assumed that five would be the most helpful, since it was the highest number (i.e. 5 out of 5 was the best). This student could be an outlier, or perhaps other students made this mistake as well.

When looking at the results of student preferences to student and teacher feedback, a clear pattern could not be identified from the initial, pre-treatment survey questions (Table 6 & Table 7).

Table 6
Student Preference for Student Generated Feedback

	Strongly Disagree	Disagree	Agree	Strongly Agree
Period 2 (N= 21)	2	1	9	9
Period 3 (N= 20)	1	4	6	9
Total (N= 41)	3	5	15	18

Table 7
Student Preference for Teacher Generated Feedback

	Strongly Disagree	Disagree	Agree	Strongly Agree
Period 2 (N= 21)	2	6	6	7
Period 3 (N= 20)	1	4	10	5
Total (N= 41)	3	10	16	12

When asked if students preferred writing their own feedback, eighty percent agreed that they preferred writing their own feedback and seventy percent said that they preferred teacher generated feedback. These numbers contradict each other and this could have partly been due to students not understanding the survey question. Modifications were made to the second survey, as well as student interviews, to eliminate this issue.

For the second student surveys, instead of two separate questions, I created a scaled question between teacher feedback and student generated feedback to identify a true preference (Table 8).

Table 8
Student Preference for Feedback

	All Student Feedback	Mostly Student	Mostly Teacher	All Teacher Feedback
Period 2 (N= 17)	1	4	8	4
Period 3 (N= 21)	1	2	12	6
Total (N= 34)	2	6	20	10

From the results of this survey question, it appears that students seem to favor teacher generated feedback. To verify the results of this question, I also created a

question that asked students their perceived value of the different feedback methods (Table 9 & Table 10).

Table 9
Student Perceived Value of Teacher Feedback

	Strongly Disagree	Disagree	Agree	Strongly Agree
Period 2 (N= 17)	1	1	3	12
Period 3 (N= 21)	1	3	4	14
Total (N= 34)	2	4	7	26

Table 10
Student Perceived Value of Student Feedback

	Strongly Disagree	Disagree	Agree	Strongly Agree
Period 2 (N= 17)	0	2	9	6
Period 3 (N= 21)	1	4	7	9
Total (N= 34)	1	6	16	13

From Table 9 and Table 10 it appears that students find both formats of feedback to be of value, but feel stronger about the teacher feedback. Some of the student comments to support this idea include that the teacher feedback is more accurate and feedback may include what teachers are looking for in a particular answer.

The short response answers why students found value in their own generated feedback revealed another pattern. Both before and after treatment, it appeared that a majority of students preferred to write their own feedback and found value in their feedback.

A common concept that students discussed was the ability to write in their own words and correct their mistakes. As one student stated, “My own feedback is useful because it helps me go over what I need to know. Additionally I know myself and my study habits which also help.” Students preferred the feedback that is tailored to their individual learning. Another student specified that the teacher feedback was “Not personalized, not enough.” A reoccurring response was that students liked to put things in their own words.

Several students indicated that this was better for their retention. One student said, “Because then it is in my brain and I understand what I got wrong rather than looking at what the teacher said and reading it.” Several students also discussed a preference for the short turnaround time when writing their own feedback. In class when giving a formative assessment that students will grade, students often take the quiz and then write feedback immediately after. When I grade them, there is normally a day or more between the formative assessments and when students get their assessments returned.

On the other hand, some students expressed that they would just prefer the teacher to provide all of the feedback. There were a few students that indicated that they did prefer the teacher feedback because they were unsure what to write or because they did not fully understand the concept yet. One student indicated that they were worried about writing down the incorrect answer. Another student said, “They know more about the subject than I do and will give me great feedback to look upon.”

As a teacher, this may mean that I need to model better ways for students to generate their own feedback or find a more resourceful way to getting detailed feedback

for students. The results of the survey also provided a pattern for what attributes students are looking for in their feedback.

From Figure 7 it appears that a majority of students found comments to be the most useful characteristic of their feedback. Teacher comments and student comments have a similar number of responses, with more students saying that their own comments were the most valuable part of feedback.

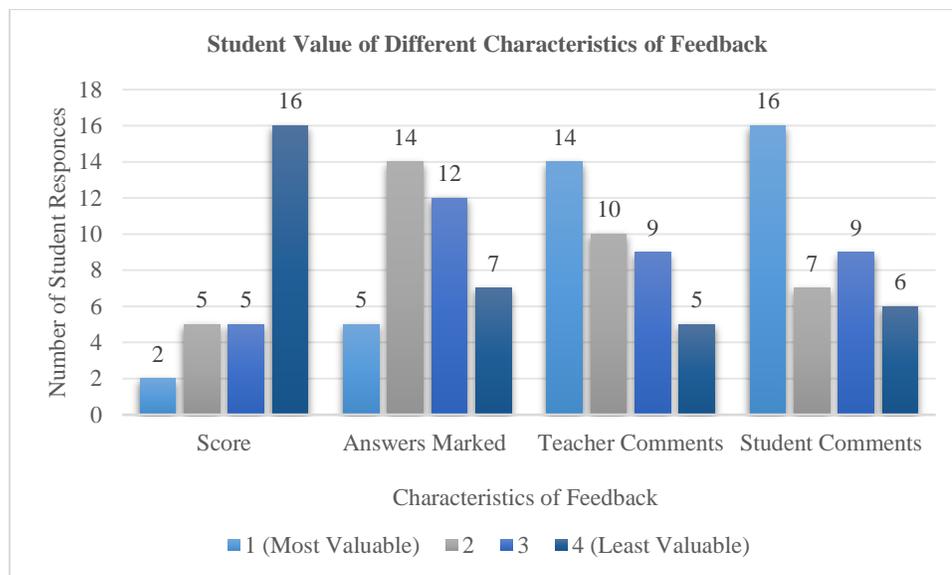


Figure 7. Student value of different characteristics of feedback, ($N=38$).

This supports the idea that students benefit from descriptive feedback, whether it is generated by themselves or by their teacher. From the data, the scores alone seem to be one of the lowest priorities for what students find beneficial for studying. This pattern supports the idea that the score alone does not help correct a student's misconceptions or improve their learning.

Student Interviews

At the conclusion of each unit, I had informal discussions with my classes about each feedback method. Many students seemed to like the writing their own feedback, while other students preferred being provided with the feedback. Interviews were then conducted to gain further insight on student opinions about different styles of feedback for assessments. The interview times were not arranged beforehand but rather opportune times, such as after class or when a student came in for extra help. I tried to keep the interviews informal to make the process less stressful for students. Some interview questions were directed to the class in general, where others probed deeper into what students thought about feedback. A full list of the interview questions can be found in Appendix F.

Table 11
Student Interview Panel Demographics

Student	Class Period	Grade at Time of Interview	Student Identifies as Male/Female	Student With 504	Students with IEP
A	Second	A	Male	No	No
B	Second	C	Female	No	Yes
C	Second	D	Male	No	Yes
D	Six	C	Male	No	No
E	Six	C	Female	Yes	No
F	Six	B	Female	No	Yes

Note. (N=6).

I chose three students from each of the two class periods to interview. I selected students with a range of overall grades in biology. Some students, like student A or student F, often perform well on assessments. Other students, like student B and student C, often do not pass the end of unit assessments. Student B and student C also have I.E.Ps

and receive certain classroom accommodations such as extra time on assessments or assessments read aloud. Student E was the only student with a 504 plan in the panel. This 504 plan pertains to her medical condition. However, she often struggles with academics and was previously in what is called the academy program. In the academy program, students do not qualify for special education, but take classes with a smaller number of students and receive more direct support from the classroom teacher.

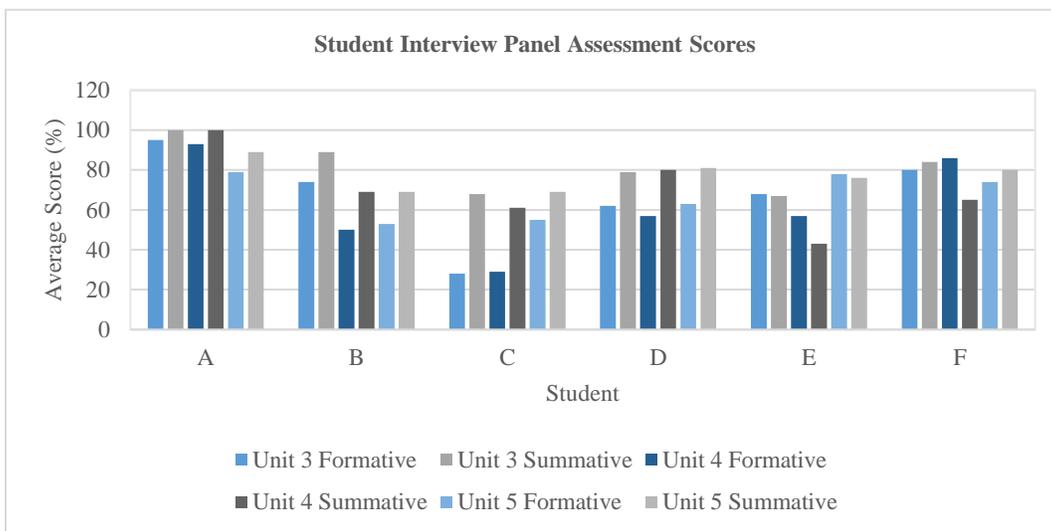


Figure 8. Student interview panel assessment scores, ($N=6$).

From the above figure, students varied in their assessment scores for the baseline, treatment one, and treatment two units. Student A did well on all three units, where student E often demonstrated a reduction between her formative and summative assessments. Student C had low formative scores, but then showed the most growth by the end of each unit.

The first question that I asked each of the students was a simple ice breaker of how they believed biology class was going. Almost all of them, including student C who had a low grade at the time, thought that the class was going well. Student F thought that

it could be going better and was hoping to raise her grade to an A by the end of the semester.

Not surprisingly, none of the students said that formative assessments were their favorite part of the class. Some students (D, E, and F) indicated when they get to design and perform their own labs. When asked why, student F explained that they found it interesting to run their own tests rather than follow a “recipe”. Student E said that some of the best parts of science classes is working with their lab groups compared to other classes that do not have as much group work.

Student B said that they enjoy when we play Kahoot or other review games in class. She said that she felt that this helped her to learn and review the material in an entertaining way. She also said that she enjoyed the competition. Student C enjoyed both teachers and our weekly routine of “High-Five Fridays”. This is not a curriculum related activity, but an opportunity for students to share out highlights of their week with their peers. Student A indicated that they like the classroom discussions and whiteboarding that we frequently do in class. He said this is where most of the material is discussed/learned. He also said, “If you pay attention, when people present and teachers ask questions, all of what you need to know is talked about.” This modeling approach is something that I first learned while teaching physics and have tried to incorporate as often as possible in biology.

When asked where students struggle in the class, almost all of them expressed some concern relating to their summative scores. Student E said, “I get pretty psyched to take the test because I am feeling pretty good about the material, but after turning it in I

normally don't feel as good about it." Student B explained that they struggled applying the material to a new scenario on assessments compared to what was discussed in class. Student C said he struggled with the fact that when he asks a question, he often gets a question in response. I have heard this response numerous times. This coincides with the teaching philosophy that I and the co-teacher in his class period share. A huge component of the learning process is discovering answers through your own inquiries to make the learning meaningful.

When students were asked what the purpose of formative assessments are, the general response was that it was to see how they are doing with the material. Student C said that formative assessments were to let the teachers in the room know who knew the material before the "actual test".

Student B elaborated and explained that the formatives let her know where she is struggling and if she needs to come in for help. She also said that they help give her practice scenarios to review for the test. As a teacher, it was reassuring to hear a student explain the formative assessment process in this way. Student F said something similar and said that formatives let her know what to study. From the interviews, this reoccurring theme to using formatives to know what to study continually came up. This was curious to me because it seemed to conflict with how students responded in the survey.

I used this to transition into the feedback on formative assessments and what they found to be valuable about formative assessments. When asking about teacher feedback, all of the students said that they find the feedback to be useful. Student E said that the

feedback provides a, “validation that I understand the material.” From this conversation, the student was referring to simple, error flagging feedback.

When I asked about the teacher comments, many students mentioned that they benefit from the details and questions added because it lets them know “exactly” what to put in their answers. What I found interesting is that Student A, Student D, and Student E all discussed writing their own comments in addition to the teacher feedback on the quiz. Student E said, “I think it is more valuable to me to write my own feedback on my assessments because I understand what I did wrong better.”

When referring to student feedback, many of the interviewed students conversed about being able to put the feedback in their own words. Student A said, “By writing my own feedback it helps me to easily go back and look at the red writing to remember what mistake or things I thought were important for the summative assessment.” Student B also added that, “I think that when we get feedback early on right after those assessments then it's easier for me to retain the information.” Student C expressed a concern about struggling to paraphrase when the quizzes are being reviewed and feeling like they missed information when responsible for writing their own. These interviews, along with all of the other data collected, helped me to form conclusions about formative feedback in the classroom.

INTERPRETATION AND CONCLUSION

The main question for this action research was to determine how in a science course different feedback methods on formative assessments would impact a student’s summative score.

Based on the literature review, students seem to benefit the most from detailed feedback that can help modify their learning. From student surveys and interviews, this also seemed to be true. Error flagging helps to show students what was correct from their assessment, but not *how* to correct their mistakes.

Students prefer feedback that will be used as a tool for them to “study” in the future. As a teacher this means that students are utilizing this feedback to help close the loop between what they once thought and what they now know. This was evidenced by a greater number of students using formative assessments as a study tool after the two treatment methods. In general, learners prefer when this feedback is generated by their teacher. This could be due to the fact that students view the teacher as the expert or that some students struggle to confidently write down all that they believe is necessary. However through teacher observations and student conversations many students benefit from writing their own feedback. This is because it is personalized and tailored to their own learning.

From the quantitative data collected during this study, there does not appear to be a direct correlation between utilizing simple feedback or descriptive feedback. Student generated feedback had the highest growth and lowest number of students who failed. This number was only by a small margin. There are several factors that could have contributed to this pattern. One idea is that each unit was not the same difficulty level for students. The unit for the baseline unit (DNA) tends to be a unit where students do better in comparison to the treatment units (cell cycle/ meiosis). Another idea is that students sometimes have different effort levels based on the time in the semester. Typically

towards the end of the semester, like the cell cycle unit, some students tend to put their best foot forward while going into finals.

Aside from the quantitative data, when students create their own feedback it increased their classroom engagement. While researching this subquestion, a number of articles discussed making students an integral part of the formative feedback cycle. Too often students are disengaged in their feedback. When students are involved in generating their own feedback it is more meaningful to their learning. They can discern where they made mistakes and reflect on their work to make corrections in the future.

By conducting student interviews and surveys, it became apparent that some students do not like to generate their own feedback because it is additional work. This passive behavior does not advance a student's understanding of the content. Several students commented on how creating their own feedback had a greater impact on their learning. Teacher observations and student work samples provided evidence of this student engagement. When the feedback is simple or teacher generated, there are always some students who "check-out" during this time. For example, when a student is asked a question as an assessment is reviewed and they are unaware of which questions the class is discussing. As a teacher I noted less of this behavior and more students on task when writing their own feedback. Student work samples show extensive student-created feedback on quizzes.

Research from the literature review also indicated that when students are engaged in the feedback process, it may lead an increase in student motivation. The student surveys lacked enough detail in their formatting to quantifiably address this question.

However during a student interview, a student provided an explanation as to how the feedback helped with her motivation.

When a student is provided simple feedback, it just tells them that they did something wrong. This can be discouraging and in some cases can cause students to shut down. I have observed this throughout my teaching when a student does poorly on a quiz and does something like flip their quiz over when it is reviewed or toss the paper in the trashcan as they exit the room. Students focus on what they did incorrect, rather than focusing on the positive what they have already learned and how they can grow in the future.

What I observed in my classroom during the treatment units, is that students were more open to the annotations, especially those that were self-generated. Learners did not seem to be as focused on marking the answer correct or incorrect. Often when I would collect the quizzes during the second treatment method, students would have a number of comments on their quiz but forget to add up their total points. When students are provided with corrective feedback, it provides them with the means to modify their learning and correct their mistakes. As the student in the interview said, it makes it “more manageable and less intimidating.” Detailed, descriptive feedback provides encouragement, rather than discouragement, which could increase student motivation.

My final subquestion pertained to which method of feedback seemed to be the most time effective for teachers. Through my own observations, students generating their own feedback saved the most time and had the smallest turnaround time for students. On average, to grade a class of formative quizzes, it took anywhere from fifteen minutes to

an hour outside of class. This range of time depended on length of the quiz and complexity of the feedback. When students created their own detailed feedback, on average it took less than ten minutes of class time and engaged the students in the feedback process.

These formative quizzes could be entered within the class period and returned to the students before they left class for the day. As discussed in student interviews, this helps for students to immediately address their misconceptions. This also saved an immense amount of time for the teacher in the classroom and created less papers for a student to carry around.

Through this action research, it is apparent that students benefit the most from descriptive feedback. This study was not able to support this with quantitative data, but qualitatively through a review of current literature on the subject, classroom observations, and student responses. When students create their own feedback, it also increases their engagement, which can motivate some students. Student generated feedback also decreases the amount of time between assessment and feedback to help student learning, while saving the teacher countless hours of grading.

VALUE

From this study there are numerous impacts to my teaching that I will continue to use as I grow professionally. One overarching theme is the value of formative assessments. These types of assessments are often given as a checkpoint for students and teachers to identify how learners are progressing with the material. Often educators use these assessments to look at overall patterns of *what* students' responses were within the

class. While this can be beneficial in many circumstances, it does not allow of an analysis of individual student answers.

Through this action research, I found myself concentrated on individual student answers and *why* they responded in such a manner. This allowed for a greater understanding of where students were struggling and what misconceptions they may possibly had. This created a foothold for differentiated instruction that I continue to develop today.

Due to this research, I have really begun to utilize the lessons I create after a formative assessments as a form of differentiated instruction to assist students with their learning. There were numerous methods that I found to be valuable. For example in a co-taught biology class when an assessment is reviewed, class grouping can be used between students who did well and those who struggled with the formative. When the formative is then reviewed with the group that understood the material, the assessment can be discussed quickly allowing for an extension of the content. For the smaller group of students who did not understand the material, an in-depth look at the quiz with additional direct instruction can then be used to improve student understanding.

Another method that I have found to work well is to allow students to improve their formative scores by completing additional assignments and corrections to their previous quiz. Formative assessments are only a small percentage of a student's grade but the grade improvement is an incentive for some students. This helps students to better prepare for the future summative assessment. For students with less motivation,

sometimes this additional work will sometimes need to be assigned to in order for it to be completed.

Formative assessments are only valuable to the learner and teacher if they can increase student learning. Through classroom surveys and discussions, students see the value in formative assessments and a correlation to their future grade. One of the most crucial components to this valuation is the feedback that a student receives. This project validated to me how much students benefit from detailed feedback that will provide a path for students to improve their understanding. This feedback can be student or teacher generated. Students see the value from teacher feedback because of their expertise in the subject area. Students also see value in their own feedback because it can be directed to their own learning instantaneously. Although time consuming, a combination of both methods of feedback also appears to work well. I sometimes will provide students with a few comments on a formative assessment, then then review the quiz in class and have students create additional comments.

One aspect of feedback that I have tried to improve upon due to this project is creating detailed feedback that is self-explanatory. During the first treatment unit where only teacher feedback was provided, regularly within a class period I would have a student ask me to explain a comment or an explanation that I had wrote on their paper. To me, if a student does not understand what is meant by the teacher comments than the feedback is useless.

I now attempt to be clearer in my feedback that I now provide students. One method that I have used to creating a feedback comment key. When students take an

assessment and I find myself writing the same thing often I will create a key that associates a number or abbreviation to a comment. Then when the quiz is reviewed during class, I can project this key for students that explains each comment. When used correctly, I find there to be less questions about what things mean. Although there is some time investment upfront, this also saves time when grading student assessments.

This is just one method that can be used to help provide students with feedback to students to help them grow. From student interviews and surveys, it does seem best practice to use a variety of methods to provide students with feedback. When the same method is utilized frequently, there is a decrease in student engagement and students become uninterested to classroom review sessions and decrease. This is why it is essential to utilize various methods.

Some methods that have been modified from the conceptual framework include utilizing different colors while creating feedback. For example, a student takes a formative quiz in black ink or pencil and then the teacher then utilizes a red pen to provide feedback. When the assessment is then reviewed, students use a blue pen to write in their own comments. Students then have a way to identify what they knew at the start, comments from their teacher to correct misconceptions, and additional notes to themselves to direct their individual learning.

Another method I have used has students create an answer key with their lab group after they have completed the quiz individually. A teacher can provide the feedback on the original student copy or a student can add additional notes in a different color pen after the key has been created. A variation of this method is to have lab groups

to become “experts” on a particular questions or scenario from a formative quiz. They are then asked to create a whiteboard or Google Slide to fully explain their answers. This information can then be presented to the class via a gallery walk or classroom discussion. What seems to work well about this method is that students utilize reciprocal teaching to explain the answer to their peers, therefore increasing their own understanding. After this project, I hope to continue to develop new methods of engaging students in the feedback process.

Although the data collection for this particular project maybe completed, the principles will have a lasting impact on my pedagogical practices. As a result of sharing this information to the Master of Science in Science Education.at Montana State University and Naperville Central High School communities, hopefully this will impact the teacher methods of others as well. This research confirmed how essential student feedback is to student learning. Feedback for students needs to be descriptive in nature and provide students with enough guidance to improve their learning. Students need to be an integral part of this feedback loop and a variety of methods must be used to stimulate student engagement. The next steps in this field of educational research may include analyzing the relationship between some of these different methods and student learning. Overall, this process has led me to a tremendous amount of growth as an educator and professional. Research is the driving force behind better teaching practices that ultimately leads to improved students learning.

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APPENDICES

APPENDIX A
IRB EXCEPTION



INSTITUTIONAL REVIEW BOARD
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MEMORANDUM

TO: Michael Schultz and Walter Woolbaugh
FROM: Mark Quinn, Chair *Mark Quinn CJ*
DATE: November 18, 2018
RE: "The Effects of Formative Assessment Feedback on Student Learning" [MS111818-EX]

The above research, described in your submission of November 10, 2018, 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.

APPENDIX B

DATA MATRIX FOR ACTION RESEARCH

Research Questions	Data Collection Methodologies						
	Literature Review	Student Surveys	Student Interviews	Teacher Reflection Journal	Student Work Samples	Formative Assessment Scores	Summative Assessment Scores
Main Topic: - How does the feedback method for formative assessments impact students' high school biology summative assessment scores?	X	X	X	X		X	X
Subquestion One: - How do different feedback methods on formative assessments impact student engagement?	X	X	X	X	X		
Subquestion Two: - How do different feedback methods on formative assessments impact student motivation?	X	X	X	X			
Subquestion Three: - What methods of creating detailed feedback on formative assessments are most time effective for teachers?	X			X	X		

APPENDIX C

STUDENT GROWTH INSTRUMENT SAMPLE DATA

Student Name	Score on Formative Assessment One (%)	Score on Formative Assessment Two (%)	Score on Formative Assessment Three (%)	Average Score on Formative Assessment for Unit (%)	Score on Unit Summative Quiz (%)	Score on Unit Summative Test (%)	Average Score on Summative Assessment for Unit (%)	Gain Score	Average Student Growth (%)	8%
	100%	92%	94%	95%	93%	100%	97%	1%		
	94%	75%	102%	90%	80%	100%	90%	0%		
	56%	75%	70%	67%	73%	92%	83%	16%		
	78%	83%	80%	80%	87%	82%	84%	4%		
	56%	83%	42%	60%	60%	71%	66%	5%		
	56%		80%	68%	40%	58%	49%	-19%		
	67%	58%	74%	66%	60%	89%	75%	8%		
	67%	83%	82%	77%	73%	92%	83%	5%		
	78%	50%	76%	68%	67%	82%	74%	6%		
	56%	67%	80%	67%	87%	61%	74%	6%		
	89%	67%	98%	85%	78%	97%	88%	3%		
	100%	83%	94%	92%	80%	88%	84%	-8%		
	72%	92%	76%	80%	87%	79%	83%	3%		
	33%	83%	80%	66%	80%	63%	72%	6%		
	89%	67%	100%	85%	93%	89%	91%	6%		
	78%	67%	86%	77%	100%	68%	84%	7%		
	56%	0%		28%	73%	68%	71%	43%		
	56%	75%	82%	71%	80%	82%	81%	10%		
	44%	75%	80%	66%	87%	82%	84%	18%		
	44%		72%	58%	87%	84%	85%	27%		
	56%	75%	80%	70%	93%	79%	86%	16%		
Average				72%		81%	80%	7.83%		

APPENDIX D

PRE-TREATMENT STUDENT SURVEY INSTRUMENT

1. Name (optional)_____
2. What is your current grade in biology?
A B C D F
3. If I enjoy a class, I am motivated to succeed.
 - a. Strongly Disagree
 - b. Disagree
 - c. Agree
 - d. Strongly Agree
4. I currently enjoy my Biology class.
 - a. Strongly Disagree
 - b. Disagree
 - c. Agree
 - d. Strongly Agree
5. How much of your free time outside of class do you spend studying for all of your classes?
 - a. 0-1 Hours
 - b. 2-3 Hours
 - c. 4-5 Hours
 - d. 5+ Hours
6. During an average week, how many hours do you spend looking over your Biology notes, formative quizzes, and other course materials?
 - a. 0-1 Hours
 - b. 2-3 Hours
 - c. 4-5 Hours
 - d. 5+ Hours
7. What materials do you use to prepare for Biology summative assessments? (check all that apply; please specify if selecting other)
 - a. Daily Class Slides/Notes
 - b. Lab Notebook
 - c. Formative Assessments
 - d. Other: _____

8. Consider the resources available to you during the first unit of biology. Select 1 for the most helpful and 2 for the next most helpful and so on.
- _____ Daily Class Slides/Notes
 - _____ Lab Notebook
 - _____ Formative Assessments
 - _____ Study Guide
9. I prefer writing my own feedback on formative assessments.
- a. Strongly Disagree
 - b. Disagree
 - c. Agree
 - d. Strongly Agree
10. Why did you answer the way you did in the above question?
11. I prefer when the teacher provides feedback on formative assessments.
- a. Strongly Disagree
 - b. Disagree
 - c. Agree
 - d. Strongly Agree
12. Why did you answer the way you did in the above question?
13. I find the teacher provided feedback on formative quizzes to be valuable for studying and improving my assessment scores.
- a. Strongly Disagree
 - b. Disagree
 - c. Agree
 - d. Strongly Agree
14. I find the feedback I create on formative quizzes to be valuable for studying and improving my assessment scores.
- a. Strongly Disagree
 - b. Disagree
 - c. Agree
 - d. Strongly Agree
15. The type of feedback (teacher created vs student created) I receive on formative assessments impacts my grade.
- a. Strongly Disagree
 - b. Disagree
 - c. Agree
 - d. Strongly Agree

16. Describe the characteristics that are necessary for feedback on formative assessments check all that apply; if selecting other please specify).
- a. Score
 - b. Answers marked correct/incorrect
 - c. Teacher comments
 - d. Student comments
 - e. Other: _____ (please specify)
17. Consider the feedback provided to you during the first unit. Select 1 for the most helpful and 2 for the next most helpful and so on.
- _____ Score
 - _____ Answers marked correct/incorrect
 - _____ Teacher comments
 - _____ Student comments

APPENDIX E

POST-TREATMENT STUDENT SURVEY INSTRUMENT

1. Name (optional)_____
2. What is your current grade in biology?
A B C D F
3. If I enjoy a class, I am motivated to succeed.
 - a. Strongly Disagree
 - b. Disagree
 - c. Agree
 - d. Strongly Agree
4. I currently enjoy my Biology class.
 - a. Strongly Disagree
 - b. Disagree
 - c. Agree
 - d. Strongly Agree
5. During an average week, how many hours do you spend studying or reviewing for all of your classes in total?
 - a. 0-1 Hours
 - b. 2-3 Hours
 - c. 4-5 Hours
 - d. 5+ Hours
6. During an average week, how many hours do you spend looking over your Biology notes, formative quizzes, and other course materials?
 - a. 0-1 Hours
 - b. 2-3 Hours
 - c. 4-5 Hours
 - d. 5+ Hours
7. What materials do you use to prepare for Biology summative assessments? (check all that apply; please specify if selecting other)
 - a. Daily Class Slides/Notes
 - b. Lab Notebook
 - c. Formative Assessments
 - d. Class Handouts/ Worksheets
 - e. Study Guide
 - f. Other: _____

8. Consider the resources available to you during the first unit of biology. Select 1 for the most helpful and 2 for the next most helpful and so on.

_____ Daily Class Slides/Notes
_____ Lab Notebook
_____ Formative Assessments
_____ Class Handouts/ Worksheets
_____ Unit Study Guide

9. I enjoy when the teacher provides feedback on formative assessments.

a. Strongly Disagree
b. Disagree
c. Agree
d. Strongly Agree

10. I find value in the feedback the teacher provides on formative assessments.

a. Strongly Disagree
b. Disagree
c. Agree
d. Strongly Agree

11. Why did you answer the way you did in the above question?

12. I enjoy writing my own feedback on formative assessments.

a. Strongly Disagree
b. Disagree
c. Agree
d. Strongly Agree

13. I find value in writing my own feedback on formative assessments.

a. Strongly Disagree
b. Disagree
c. Agree
d. Strongly Agree

14. Why did you answer the way you did in the above question?

15. The type of feedback (teacher created vs student created) I receive on formative assessments impacts my summative grade.

a. Strongly Disagree
b. Disagree
c. Agree
d. Strongly Agree

16. In biology, what style of feedback do you prefer to receive on formative assessments?
- All Student Created Feedback
 - Mostly Student, Some Teacher Feedback
 - Mostly Teacher, Some Student Feedback
 - All Teacher Created Feedback
17. Describe the characteristics that are necessary for feedback on formative assessments check all that apply; if selecting other please specify).
- Score
 - Answers marked correct/incorrect
 - Teacher comments
 - Student comments
 - Other: _____ (please specify)
18. Consider the feedback provided to you during the first unit. Select 1 for the most helpful and 2 for the next most helpful and so on.
- _____Score
- _____Answers marked correct/incorrect
- _____Teacher comments
- _____Student comments

APPENDIX F
STUDENT INTERVIEW QUESTIONS

1. How is biology going for you?
2. What parts of biology class do you most enjoy?
3. What parts of biology do you struggle with?
4. What is the purpose of formative quizzes?
5. How did you use the feedback from formative quizzes?
6. What did you like/ dislike about the feedback the teacher provides?
7. What did you like/ dislike about writing your own feedback?
8. Which method did you find to be most beneficial for your learning? Why do you think that is?