

MEASURING THE EFFECTIVENESS OF PROJECTS AND STUDENT LEARNING
OWNERSHIP THROUGH DIFFERENTIATED ASSESSMENTS IN SCIENCE

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 2014

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July 2014

ACKNOWLEDGEMENTS

I would like to thank my colleagues Caryn Purcell and David Kucher, and my committee members Dr. Eric Brunsell, Dr. John Winnie Jr., and Dr. Peggy Taylor, whose counsel and advice during the planning and revision stages of this project were both helpful and greatly appreciated.

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ABSTRACT

The purpose of this study was to measure the effect of choice in assessment style in the science classroom, and to measure the reliability of projects as assessment instruments relative to teacher-generated tests. I also planned to measure student attitudes towards having choice in the style of their assessment, and to see if student ownership of learning increased with the use of formative assessments while completing the project. The intervention took place over a four week period in March and April of 2014, and it involved 23 ninth grade biology students at New Canaan Country School, a small independent day school in New Canaan, CT. During the intervention, students first completed a unit on DNA structure and replication. One group was assessed with a test, and the other group was assessed on a project in the format of their choosing. A crossover study model was used here, so that at the end of the second unit on protein synthesis, each group had completed both a test and a project. Data collection involved both quantitative and qualitative measures: a comparison of those tests and project results, student attitude surveys, teacher observations, and a student questionnaire. Results suggest that projects are a reliable assessment instrument; they were largely preferred by students, and students were more involved in the process of their own learning, demonstrated by reported time spent on task and effectiveness of formative assessment pieces.

INTRODUCTION AND BACKGROUND

New Canaan Country School's mission statement charges teachers with the responsibility "*to guide students to reach their intellectual, creative, moral, and physical potential.*" In order to do that, teachers must first work to understand how their students learn best, help students take ownership of their learning, and then work with them towards reaching their potential.

New Canaan Country School is a private day school in New Canaan, Connecticut that runs from Pre-K to 9th grade. There are just over 600 students in the school, about 60 students per grade. The ninth grade is smaller; approximately a third of the class leaves after 8th grade to enroll in public high schools in the area or to attend private day or boarding schools. There are currently 36 students in the ninth grade. This is an affluent area, and the school has both substantial financial resources and the high-pressure parent body that sometimes comes along with that. My class has more socioeconomic than ethnic diversity. In general, our students and their parents are involved; they do their work; they want to do well, and they're either curious about the material for the sake of knowledge, or they're concerned enough about the grades that they'll need to get into their next school to stick with it.

I teach seventh and ninth grade science. I have two sections of ninth grade non-honors biology. There are 9-14 students in each section, and so far, they've shown that they're doing their work, they care about what we're talking about, and for the most part, they ask questions when they have them. I have several students who have demonstrated a marked disparity between their performance on tests and their performance on projects, which tends to be higher. Anecdotal evidence for low performance on tests suggests a

combination of test anxiety, uneven preparation, difficulty with reading comprehension, difficulty with expressing their ideas clearly in writing, individual problems with certain types of test items (multiple choice), etc.

I suspect that many low-achieving students would appreciate the opportunity to show what they are capable of in ways that might be different from what their teachers ask of them on a daily basis. Asking students to choose a method that allows them to demonstrate mastery of a topic requires more involvement and ownership in their learning than they are typically used to; therefore, it is important to involve students in the process, and to give them the tools for enhancing their academic strengths and improving their weaknesses.

To this end, I needed to develop a system of instruction to connect with the learning styles of a broad range of students, to use a system of assessments that allowed students to demonstrate mastery of information in a way that they were most comfortable with, to guide students to their own awareness of how to best demonstrate their mastery, and to help them monitor their progress towards achieving their goals.

The three research questions that I set out to study were: 1) In what ways does the element of choice in assessment style increase the reliability of my assessments; do those assessments accurately reflect what the student knows? 2) How will this process change student attitudes towards assessments such as written assignments, projects, or tests? 3) How will the inclusion of choice and formative assessment instruments increase student ownership of their learning?

CONCEPTUAL FRAMEWORK

Teachers and researchers are constantly trying to address the question of how to improve student learning. You could say that it is the central question of education, the question common to all good teachers: improve teaching with the goal of improving student learning. The diversity lies in the answers to that question, how we choose to improve our craft, and those answers can be broken into two main groups. First, we can look at aspects of our teaching that can change, what could be called teacher-centered reform. This includes details of instruction and assessment, how we present information, guide students, and find out what students know or are capable of doing. Another approach deals more directly with the malleability and growth potential of students, what we can call learner-centered or student-centered reform. This includes strategies like working to improve student motivation, self-regulation, goal setting and planning, or their executive function skills. It also includes the study of learning styles, the idea that there might be one “best way” to reach each learner.

Many teachers have followed this line of thought – trying to match learner style with instructional method – and it does not always work (Cassidy, 2004; Klein, 2003; Loo, 2004; Pashler, 2008). Cassidy (2004) explains that customizing learning style to learner preferences can be difficult because there are multiple definitions for what the different learning styles actually are. They are not saying that it’s a bad goal, just that “operationalizing learning style is a necessary but highly problematic endeavor” (p 440). Cassidy is not the only one sharing words of caution. Klein (2003) describes several methods to coordinate the modality of instruction with student learning styles, including matching “modality-specific lessons” to student preferences; students choosing activities

that fit well with their preferred method; and regularly switching teaching modality on a schedule that gives students a broad swath of experiences, one that is sure to match up with how they like their learning. But many teachers forge ahead with these ideas because they sound like they make sense, without consideration of whether the research in the literature supports their use. Klein and others (Kavale & Forness, 1987; Snider, 1992; Stahl & Kuhn, 1995; Yates, 2000) believe that many learning style theories are far more popular than what the research supports, and that their popularity “contrasts sharply with the devastating results of research on these constructs” (Klein, 2003, p 47). As an explanation, Pashler and colleagues (2008) described that while many people express a preference for a particular style of information, they are able to learn in many different modalities, and because it is a difficult thing to measure, “very few studies have even used an experimental methodology capable of testing the validity of learning styles applied to education” (p 105).

At the same time, there is still a strong sense among teachers that this is a good idea, even if the research does not support it. This is not to say that they should ignore the research; many teachers are simply unaware of it. Good teachers work to explain concepts in ways that make sense to students – if a student doesn’t understand a particular analogy and asks for clarification, what teacher wouldn’t try to find another way to make the point clear? The fault lies not in varying instruction – multiple representations of a concept can be helpful to many learners – but in interpreting that practice as matching instruction to student preference. Tomlinson and Kalbfleisch (1998) write that many educators understand the importance of engaging individual learners in the classroom, a situation that is compounded in complexity because students do learn in

many different ways. They suggest that it is natural that good teachers would work to try to fit their instruction to those needs and preferences. Plus, offering different challenges to each student allows them to engage at their own independent speed, at their own level. This leads to student goals focused on their individual growth, which can be presented in portfolios that show their progress in the class. In this case, the focus on individual growth may be the deciding factor, since teachers are not just varying instruction methods, but are asking students to think metacognitively about their work. In a study involving elementary children learning spelling words in different ways, Slack and Norwich (2007) found that auditory and visual differentiation had a positive effect. Retention of word spelling was higher one week after the teaching when the teaching matched the learning style in that study, suggesting that there is some basis for adjusting the type of learning style in the classroom. But this is not the whole picture.

Student engagement is a good thing, and the points that Tomlinson, Kalbfleisch, Slack, and Norwich raise above sound valid (Tomlinson & Kalbfleisch, 1998; Slack & Norwich, 2007). Many teachers do this as a matter of course, being flexible and responsible in working to reach each student in the class, but this is not the same as trying to match instruction to what they feel is a student's "best" learning style, a practice that is not supported by research. Willingham (2005) provides some clarity by explaining that although students certainly have preferences in terms of how they like to receive information, it is the content that should drive the modality, not the particulars of the receiving student brain. If a teacher is going through a unit on geography, that type of information would be best presented visually on a map, even to the children in class who are strong auditory processors. He posits that the brain does not remember the modality

of how the information “got in”, only that pieces of information become searchable after the fact because of their meaning:

"Most of what we want children to learn is based on meaning, so their superior memory in a specific modality doesn't give them an advantage just because material is presented in their preferred modality. Whether information is presented auditorily or visually, the student must extract and store its meaning" (Willingham, 2005, p 34).

Teachers are working to improve student learning in the classroom, and reinforcing meaning by explaining information in a variety of modalities may be a good idea because the presentation of each modality represents additional exposure to the material. As a contrast to this approach, one method that involves different learning styles (but not matching of modality to learning style) is the broad field of self-regulation. As students move into adolescence, they start to shift from schooling that is generally directed by parents and teachers, and towards more ownership of their learning. The way students do this is by developing skills that help them to become more independent learners: they set goals, describe steps they need in order to achieve those goals, monitor their progress, and evaluate and recalibrate when necessary. Ideally, they build confidence and momentum here, and are able to check themselves against a standard along the way.

Gettinger and Seibert (2002) describe some of the differences between “effective and ineffective studiers,” and they explain that the students who are able to self-regulate the different steps of their academic lives (including those important steps of monitoring and recalibration) are better students; they use different strategies to accomplish their goals, and they work continually to acquire new strategies for new academic situations. These

changes towards academic independence and increased responsibility correspond to similar adolescent changes in their lives outside of school, and it is fitting that teachers should challenge them in appropriate ways.

The issue of student ownership of their learning, or empowerment, is also an important one as it relates to motivation in schools. Dembo and Eaton (2000) point out that students who are empowered by the belief that learning is within their grasp can improve by learning, and using specific strategies that work for them. Once they realize that they can control their learning, they have the potential to take ownership of it because they can then choose the course of their education; it becomes student-centered.

Students must eventually take responsibility for those parent- and teacher-led forms of motivation. This is a natural and developmentally appropriate thing for them to do at some point in between middle and high school. While some do this on their own, many students must be taught the skills of self-regulation and monitoring explicitly; those skills should be taught at an early age, practiced, exercised, and reinforced year after year. Cleary and Zimmerman (2004) describe and measure the effectiveness of what they call a *self-regulation empowerment program*, which was designed for students with low motivation, poor monitoring abilities, and ineffective strategies for completing work and retaining information. These skills can be taught and coached. In contrast to those low achieving students, they report, “self-regulated learners are proactive learners who incorporate various self-regulation processes (e.g., goal setting, self-observation, self-evaluation) with task strategies (e.g., study, time-management, and organizational strategies) and self-motivational beliefs (e.g., self-efficacy, intrinsic interest)” (Cleary & Zimmerman, 2004).

Several additional studies have been done that compare habits of successful students with those of less successful students, with a view towards teaching those successful strategies to all students in order to improve performance (Gettinger & Seibert, 2002; Page-Voth & Graham, 1999; Perry, 2002). Gettinger and Seibert (2002) say that low-achieving and normally-achieving students can increase their performance in school if they learn to use metacognitive processing and study skills that more successful students are already using. Dembo and Eaton (2000) also add:

“When individuals establish and attempt to attain personal goals, they are more attentive to instruction, expend greater effort, and increase their confidence when they see themselves making progress. It is difficult to be motivated to achieve without having specific goals. Therefore, teachers need to help students set both long-range and intermediate goals for academic, personal, social, and occupational domains in their lives” (p 476).

This is an important piece of any project related to self-regulation in the classroom. It's the starting point: knowing what one wants to achieve, making a plan to get there, and then checking and monitoring progress along the way, adjusting when necessary. If students are not doing this already, they can be taught, and the research suggests that it will make a measurable difference.

Empowering students to make choices about their learning allows them to more effectively demonstrate mastery on assessments, not because of a match of modality with a particular learning style, but for the very fact that students are engaged by teachers and asked to think about their own work in the process. By involving them in the planning stages (in the generation of a scoring rubric), by asking them to set and monitor progress

towards their academic goals (by referencing that rubric during the process), and by introducing the element of student choice in assessment format, student learning will improve.

METHODOLOGY

In February of 2014, I introduced an intervention into two sections of my ninth grade biology class. I chose a specific series of units in biology (DNA structure and function; protein synthesis), and I used my two different teaching sections as treatment and non-treatment groups on alternating units. I chose to measure the effectiveness of choice on how students demonstrate mastery of information in my science class: each student in one group completed a test on the first unit and a project on the second; the other group completed a project first, and then a test. This action research project aimed to make quantitative comparisons between those two types of assessments. I structured these assessments in such a way to give me a larger sample size for research, to allow me to try a treatment unit with both sections, and to help me track student performance on these two assessments relative to type of assessment. In order to measure change in student attitudes, and to measure student attitudes relative to tests and projects in general, I gave an attitude survey before and after the action project. Students were also given the opportunity to complete a questionnaire at the end of the action project in order to share their thoughts on the process. I used formative assessments during both units as a way to measure student engagement and understanding of the material presented, and to see if students used this information in order to monitor their progress towards completion of the project or preparation for the test (Cleary & Zimmerman, 2004).

These were my research questions: 1) Are projects a reliable way to assess student mastery of information? 2) How will this intervention change student attitudes towards assessments such as written assignments, projects, or tests? 3) Does giving students choice in these assessments increase student engagement and ownership of their learning?

See Table 1 for the overview of topics and sequence of the non-treatment and treatment units.

Table 1
Schedule for Treatment and Non-Treatment Units

	UNIT 1	UNIT 2
	Feb 21 – Mar 10, 2014	Mar 10 – April 14, 2014
Group A	TREATMENT GROUP Project option for assessment on: <i>DNA Structure, function, and details of DNA replication</i>	NON-TREATMENT GROUP Test on: Protein Synthesis
Group B	NON-TREATMENT GROUP Test on: <i>DNA Structure, function, and details of DNA replication</i>	TREATMENT GROUP Project option for assessment on: Protein Synthesis

I collected quantitative data using test scores and project scores for each unit. I also collected qualitative data through the use of student surveys and questionnaires. Both groups received the same instruction over the month-long period, with as much as consistency as possible in delivery. After that instruction, Group A had several options for their Unit 1 assessment. These included creation of a model, poster, written explanation (essay), video, oral presentation, or video tutorial (defined here as any digital multimedia project containing audio and video that would be useful or instructive to another student studying this material). Group B took a test on the material covered in Unit 1.

For Unit 2, instruction was also uniform across the two groups. For their assessment, Group A took a test on the material covered. Group B had the same options listed above in order to demonstrate mastery of material. By the end of those two units, each class had completed a treatment unit and a non-treatment unit. I then compared student performance in the treatment and non-treatment groups to see if there was a measurable difference. Note: both classes were aware that they were part of this action research project; this was not a blind study. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

The project overviews and grading rubrics can be found in Appendices B, C, E, and F. The project prompt for DNA structure and replication was this:

I've suggested to you that DNA is an important molecule. Show me that it is. Your project must include the detailed structure of its nucleotides, their complementarity, and an explanation of how this molecule is copied prior to cell

division (including the role of enzymes in the process). Your project may take any form that we discussed in class, and I am open to suggestions if you have a different idea that you'd like to pursue. Please see the project overview and grading rubric on the class web page for details on scoring. Due: Feb ____, 2014.

The project prompt for Unit 2 was similar, but asked for the details and importance of the process of protein synthesis:

I've suggested to you that Protein Synthesis is an important process. Show me that it is. Your project must include accurate representations of DNA, RNA, and the primary structure of proteins, as well as correct explanations of the processes of transcription and translation. Your project may take any form that we discussed in class, and I am open to suggestions if you have a different idea that you'd like to pursue. Please see the project overview and grading rubric on the class web page for details on scoring. Due: Feb ____, 2014.

Because the assessments collected varied in format, it was important to quantify the results in a number of different ways, and I did that with the use of a grading rubric. Its categories and scale applied to the test and project options in order for them to be comparable, and to measure student learning on different assessments. The use of the grading rubric would help to answer my second research question: whether formative assessments and choice in assessment style can improve student ownership of learning and improve attitudes towards their school work.

In addition to the quantitative results from comparisons of the non-treatment test to the treatment assessment and rubric scores, I collected the following data in order to

answer my secondary research questions. The triangulation matrix with my data sources can be found in Table 2 below.

Table 2
Data Triangulation Matrix

Focus Questions	Data Source 1	Data Source 2	Data Source 3
<i>Primary Question:</i> 1. In what ways will the element of choice in assessment style increase the reliability of my assessments (do they accurately reflect what the student knows)?	Artifact; teacher-generated tests, baseline results prior to study.	Observation; look at actual test responses; do they show depth and understanding?	Inquiry; student surveys, do students feel that they've demonstrated mastery?
<i>Secondary Questions:</i> 2. How will this process (intervention) change student attitudes towards assessments such as written assignments, projects, or tests?	Attitude scale (<i>Likert</i>), before and after intervention	Student questionnaire for subjective feedback	Field notes / teacher journal as participant observer
3. How will giving students choice in these assessments increase student engagement and ownership of their learning?	Student questionnaire for subjective feedback	Formative assessment during the process	Field notes / teacher journal as participant observer

I compared responses from the survey and questionnaire with test and rubric scores to see if there was any correlation between students' voiced opinions and other less-subjective data collected. I also measured student attitudes towards formative assessments used during the process (as a way of supporting the self-regulation skills of monitoring by consulting the grading rubric, and adjusting one's preparation based on teacher feedback). This intervention took place in a four-to-five week window between the beginning of March and early April of 2014. Units were roughly equal in length.

DATA ANALYSIS

Data were analyzed to compare results within each topic unit to see if student project scores suggested more comprehensive understanding than tests on that same material (as measured by their project and test scores). Qualitative data were also collected to measure student attitudes towards tests and projects, to gauge student preference and their sense of overall preparation for each type of assessment. Student questionnaire responses showed that 82% preferred projects to tests when given the option ($N=23$). The formative assessment *Muddiest Point* exercise was used to gauge student understanding during the instruction period, so that I could adjust focus towards the areas where students needed additional clarification while students were preparing (Appendix I). That formative technique was used in conjunction with reminders to monitor progress by consulting the posted Grading Rubric (Appendices C and F). Questionnaire responses also supported the assertion that both the muddiest point and use of the rubric were effective for students (Appendix H).

Although both class sections covered the same material, were assigned the same readings, and did the same activities, their discussions and dynamics were different, naturally; the make-up of the students varies by section in ways that are beyond my control (such as the foreign language or math classes in which they are enrolled). Group A has scored consistently better on written work, tests, and projects, with a trimester average 4.08% points higher in the preceding term. These students are not sectioned by ability in biology (except that they are all in my non-honors sections), but because of scheduling constraints they happen to be in differently tracked math classes. The more

accelerated math students are in my stronger section of biology, and their scores on this project were consistent with the work they have demonstrated so far this year.

Reliability of Choice in Project Assessments

Quantitative results show slightly improved rubric-based scores on projects relative to a standard test on the same material (increase of 5.9% on Unit 1; increase of 0.27% on Unit 2). See Table 3 below for a comparison of mean scores and standard deviation within the groups.

Table 3
Treatment and Non-treatment Scores

	UNIT 1 <i>DNA Structure, function, and replication</i>	UNIT 2 <i>Protein Synthesis</i>
Group A	TREATMENT Project <i>Mean: 86.1%</i> <i>St. Dev = 4.1</i>	NON-TREATMENT Test <i>Mean: 84.28%</i> <i>St. Dev = 6.5</i>
Group B	NON-TREATMENT Test <i>Mean: 80.2%</i> <i>St. Dev = 9.7</i>	TREATMENT Project: <i>Mean: 84.11%</i> <i>St. Dev = 6.8</i>

Teacher observations and comparisons of specific test responses and project content (including diagrams and explanations) within those assessments generally found more depth and support of main ideas of the concepts covered on projects, with fewer gaps in content covered. This was an occasional problem on tests for several students,

and leaving test items blank resulted in corresponding reductions in scores. This was less common on projects. Feedback from student attitude surveys and questionnaires showed increased involvement and monitoring during the process by students, and increased time spent on projects relative to tests.

Each class scored higher on its project/treatment unit, compared to the non-treatment unit/test, regardless of the order of the treatment/non-treatment units. Group B scored four points higher on their project unit. Group A scores on the project unit were 1.9 points higher than on their test unit. Only 4 students out of 23 reversed that trend, scoring higher on the test than they did on the project. Note: in Group A, two students were outliers and scored 9-11 points higher on the test. This did not follow the pattern of the rest of the class (the test average was 1.9 points lower than the project average) for this unit. Both groups scored within normal ranges (when compared to their work in this class so far) on their test and project units.

Student Attitudes on Choice in Assessment

On the Attitude Scale Survey, I collected information from students on their sense of how accurately tests and projects measure what they know in this class (Appendix G). I collected responses before and after the treatment period to see if there was any change. Response options ranged from “strongly disagree” to “strongly agree,” and I assigned a numerical value from one to four in order to quantify their answers. The pre-treatment mean for the statement, “I feel that tests in this class accurately assess what I know” was exactly 3.0 (equal to the “agree” value). The pre-treatment mean for the statement, “I feel that projects in this class accurately assess what I know” was 3.26 (0.26 closer to

“strongly agree”). Only 3 students out of 23 responded that they feel projects less accurately assess what they know. (Two of these students scored “agree” for the test statement, and “disagree” for the project statement. One student “strongly agreed” with the test statement, and only “agreed” with the project statement – not an increase in score, but positive responses for each prompt.) All other student responses stated that projects either more accurately assess what they know, or their responses were the same for the test and project prompts. Evidence from test and project scores from the treatment and non-treatment unit were consistent with student perceptions of their performance in general.

Post-treatment responses showed a similar pattern to the pre-treatment surveys. After learning how they did on the project and test assessments, the statement scores increased from 2.81 (slightly lower than “agree”) on the test statement, to 3.21 on the project statement. This is an increase of 0.41 (towards “strongly agree”), indicating that students felt that projects in this class accurately assess what they know. Three students responded that the project less accurately assessed what they knew relative to a test. Four students in the study scored lower on the project portion of the unit than on their test portion of the unit, and anecdotally, I have heard from several students that they prefer tests simply because they take less time. Student responses were anonymous, so I don’t know if they were the same students.

From the student questionnaire, 81% of students reported positively that the project rubric score “accurately reflects your understanding of DNA replication or protein synthesis.” One student even went as far as to respond, “Absolutely.” On the test prompt of the questionnaire, 55% of students reported positively that the test score “accurately

reflects your understanding of DNA replication or protein synthesis”; 27% of students did not believe the test accurately reflected their understanding; 18% of students wrote in “kind of” or “not as much.” As a follow-up to that question, one student wrote a more lengthy answer explaining that,

“Tests are relatively short because of class time and so it does not cover everything. Also, test environments feel negative and rushed and my brain shuts off automatically because it asks for specific information that I may have overlooked. In a project, if I didn’t understand something then I could look it up and research it and use that information” (Student questionnaire, April 2014).

Change in Student Ownership of Learning

Student questionnaire responses were useful in answering the question of whether choice in assessment style increased engagement and ownership of learning. Are students more active participants during the process of completing a project, or while studying for a test? If so, how are they involved? The questions that shed the most light on this topic were related to students’ stated preference for tests or projects, their reported time spent in preparing for the test versus time spent preparing the project, students’ sense that tests or projects accurately assess their understanding of the topic, and a question about whether students feel more in control of their grade on a particular assessment type.

Qualitative results clearly show student preference for projects over tests. In response to the question, “If given the choice, would you prefer to take a test or complete a project?” 82% stated that they would choose a project. When asked why they chose the project format that they did, responses included the following: “It was the easiest way to

get my ideas across;” “posters allow me to visualize what we’re learning;” “because I like talking and explaining;” “it was easiest to explain in a video;” and “because I can show what I know.” While most students prefer projects, some do not; a thoughtful response for why tests are preferable: “[project grades] include appearance [of the project], which has nothing to do with understanding of the topic.”

Students reported across-the-board that they spent more time preparing their project than in studying for the test. The average response for “time spent preparing for this unit’s test” was 1.56 hours. The average response for “time spent completing this unit’s project” was 3.17 hours. Not one student reported spending less time on the project, although 4 students reported spending the same amount of time (preparation time reported by those students ranged from 1.5 hours to “a lot” for both their project and test). The shortest reported times for test preparation were “ten minutes,” and “not long.” The longest time reported for preparation for any test or project was six hours (one student reported this for time spent on test preparation; three students reported this for time spent on project preparation).

Regarding student involvement and their investment in the project, 70% of students responded that they felt more in control of their grade when completing a project. When completing their project, 88% of students found the rubric useful. The 12% that did not find it useful also reported that they did not consult it during the process (or only “kind of” consulted it). Regarding student sense of fairness and accuracy on the treatment and non-treatment units, students responded by and large that projects more accurately assess what they know relative to tests (81% for projects; 55% for tests).

INTERPRETATION AND CONCLUSION

The questions I set out to answer were: 1) In what ways will giving students choice in the style of their assessment affect the reliability of those assessments? 2) How will this intervention change student attitudes towards assessments such as written assignments, projects, or tests? 3) Does giving students choice in these assessments increase student engagement and ownership of their learning? The answer to my first research question is that projects are a reliable assessment instrument. They accurately reflect what students know about a topic, and they provide students with opportunity to demonstrate mastery. Evidence for this claim can be found by looking at grading rubric results, from looking at individual projects and slides for completeness of information, and by comparing those results to test scores and responses. Scores for the project unit in each group were slightly higher, but were comparable to that unit's test scores. The answer to whether choice in assessment style increases reliability would require a larger sample size and further study. Including choice was important in establishing reliability in those assessments, even if they didn't increase reliability significantly. With regard to perception of fairness and accurate assessment of their work, student responses were clearly in favor of the project option.

On the second question regarding student attitudes towards projects, there is clear evidence in the attitude survey and questionnaire responses that the majority of students (82%) prefer to complete projects instead of tests, even though they reported spending twice as much time, on average, on projects. They stated that when given the choice, they prefer creating video tutorials, posters, PowerPoint presentations, videos, and models. The reasons they stated for choosing those formats include ease of explanation, a desire

to be original, fun working on projects like videos, previous experience with a particular format, and the chance to describe what they know in an open-ended setting. Students were also comfortable sharing their perceptions of the limitations of teacher-generated tests: “I don’t remember things I write down, but I remember things when I create them,” or “the paragraph answer format for the test is not a good way of testing in a subject like science.” Some students do prefer to take tests, and there was a small cohort that fell into that category during this study (the four students that stated a preference for tests may be the same four students who didn’t feel that the project was an accurate assessment of their understanding – the questionnaire was completed after students had results from both units). Perhaps there’s less to gain from a project option if these students consistently get comparable grades on tests with less time expended.

My third research question was to assess whether giving students choice in the format of their assessment, along with the formative assessment instruments, increased student involvement and ownership of their learning. The best evidence for this claim can be found in the student attitude survey and questionnaire results. Students preferred projects, spent twice as much time completing those projects, and stated (on the whole) that they were a fair assessment of what they understood. They found the “muddiest point” prompt to be helpful during the test and project units; this formative assessment allowed students to identify elements of the topic that were giving them trouble, and to receive clarification from me on the topic. Students also stated that consulting the grading rubric was helpful during the project portion of the study, and this may be the reason that there were fewer gaps in content presented in project format when compared to test responses. Students were able to find gaps in their information during the project process,

and work to fill those gaps before completing the project. Not all students took advantage of that option, but the ones that consulted the rubric reported that it was useful.

The first question I address in my study is: in what ways will giving students choice in the style of their assessment affect the reliability of those assessments? Research offered by Klein (2003) suggests that allowing students to choose activities which fit with their preference of modality does not result in increased student success, either quantitative (improved grades) or qualitative (student satisfaction reports). My findings contradict that. Rather, the results of my action research project were consistent with research cited by Tomlinson and Kalbfleisch (1998), who explain that most students learn best in a multi-modal way. The results of both instruction and assessment during the treatment units in this study were successful in part because they took advantage of student choice; this element resulted in positive attitudes among students about their work, with a possible correlation to increased interest in the topic, and increased time spent on the project.

The results of my secondary research questions were consistent with research by Gettinger and Seibert (2002), Dembo and Eaton (2000), and Cleary and Zimmerman (2004). Use of formative assessment instruments and a grading rubric have been suggested as ways to improve student involvement and ownership of learning (Cleary & Zimmerman, 2004). Student attitude surveys and questionnaires reflected increased engagement with the material during the treatment unit, increased time spent on task relative to the non-treatment unit, and positive effects from students' self-monitoring of progress through consultation of the grading rubric throughout the process.

VALUE

This project was valuable to me in a number of ways. It caused me to reflect closely on the assessments I give, on both the tests and project options for DNA and protein synthesis. I was careful to make sure that I was assessing the same information, and I worked hard to make sure I was consistent in instruction, and in how I communicated expectations for each unit. This extra attention would be beneficial for any unit (and any assessment). Also, the addition of a formative assessment within each unit helped students to understand the topic better, and helped me to recognize parts of my instruction that could have been more clear. (For example, because the section on transcription came up on several student responses, I know that I should work to find a better way of explaining that process to the class.)

I see the value of using projects in the science classroom. There are several projects that are student and teacher favorites throughout the year in biology, and they satisfy a desire of students to be creative, to do something different, to create a tangible product, and to learn material and present it to others in a meaningful way. This idea was reinforced by several answers on the student questionnaire, and supported by positive student responses on choice, as well as how they explained different project formats that they prefer. What was new for me was to actually test the effectiveness of projects, side-by-side with tests, and to find out that they are comparable (with regard to results), and preferable (when you take student choice into consideration). The fact that students were choosing to spend up to twice the amount of time on their project option, and preferring that to studying for a test, is certainly noteworthy. I plan to take advantage of this interest

by giving more project options in my class next year, and by looking at different ways to have students explain what they know.

With more time and a larger sample size, I would be curious to find out more about the types of projects that students prefer. Are students good at choosing different project formats, or do they simply choose the project option that seems easiest? Would they improve with some mindfulness training, so that they learn which type of project would be best for a particular unit? I am interested to learn the best ways to guide students towards projects that they would be most engaged in, so that they continue to be invested in their learning, working towards completing assignments that are meaningful to them. The results of this study also point to the effectiveness of formative assessments, whether students are completing projects or preparing for tests, because formative check-ins allow students to monitor their progress relative to the goal of understanding a topic, to ask questions, and to make adjustments along the way. It also keeps them engaged during the intermediate steps, so that they don't have the option of procrastinate-and-cram. Along with the overall goal of increasing student engagement, the elements of projects, choice, and formative assessment are positive outcomes of this study. I look forward to using that knowledge to help all learners in my class in the future.

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APPENDICES

APPENDIX A

UNIT 1 (DNA) TEACHER-GENERATED TEST (NON-TREATMENT)

Nucleic Acids Test – structure, function, and replication

9 Lilley Bio Mar 2014

Modified True/False

Indicate whether the sentence or statement is true or false. If false, please change the identified word or phrase to make the sentence or statement true.

- ____ 1. The replication of a DNA molecule results in four copies of DNA.

- ____ 2. If a nucleic acid contains *uracil*, it is DNA. _____
- ____ 3. The heritable genetic information of an organism (what it *inherits*) is stored in the molecule called ribonucleic acid (RNA).

- ____ 4. The enzyme that adds new nucleotides to the leading strand of DNA is called DNA ligase.

Completion

Complete each sentence or statement.

5. The order of nitrogenous bases in DNA determines the order of _____ in proteins.
6. The nitrogenous base *thymine* bonds with _____ .
7. If six bases on one strand of a DNA double helix are AGTCCA, what are the six bases on the complementary section of the other side of DNA? _____
8. What are the two components of the backbone (or “side rails”) of the DNA molecule?

Short Answer

9. What are mutations, and when do they happen?
10. Explain what’s meant when the two strands of DNA are said to be *antiparallel*.

11. Explain why are there multiple *replication bubbles* along a strand of replicating DNA.
12. Please draw and label three **connected** DNA nucleotides and their parts (*on the same side of the strand*). You may choose your favorite three nitrogenous bases. Label the three parts and the 3' and 5' ends.
13. Using the short piece of DNA that you drew in question 12, write the 3 DNA nucleotides that would be attached to it on the other strand (you may abbreviate with capital letters).

LONGER ANSWERS (*please answer these on a separate piece of paper. You may write or type.*)

14. List the order of steps that happen during DNA synthesis.
15. Explain the difference between synthesis of the *leading strand* and synthesis of the *lagging strand* of DNA. You may draw a diagram if it helps you to explain.
16. What is *apoptosis* and why is it a good thing?
17. Why do cells need to replicate their DNA? (It seems awfully complicated and costs a lot of energy. Is it worth it?)
18. What are the four enzymes that we studied that are involved in DNA replication, and what does each do?

APPENDIX B

UNIT 1 (DNA) PROJECT GUIDELINES (TREATMENT)

February 2014. DNA Structure and Replication Project

This short project will cover two things: an explanation (and visual representation) of the basic structure and function of DNA, and a description of the process of DNA Replication (how and when it is copied).

Part 1: DNA Structure. You must show the following:

1. The structure of DNA nucleotides (sugar, phosphate, and the 4 different nitrogenous bases, how they fit together/complementarity)
2. The arrangement of those nucleotides into the shape of a double helix
3. Proper alignment and representation of 3' – 5' direction of strands

Part 2: DNA Replication. You must show the following:

1. Explain the *process* and *outcome* of semi-conservative replication, including the role of the enzymes topoisomerase, helicase, DNA polymerase, and DNA ligase. You should also show origins of replication, replication bubbles, and the difference between synthesis of the leading strand and lagging strands.
2. A brief explanation of *why* DNA replication is important to cells and organisms. This should be a paragraph that accompanies your model, or is included within your video, poster, or animation.

You may show this electronically, with video or animation and narration, a digital tutorial, with a model, or in words and pictures, on a poster, or any combination of those. *The slides, photos, and images you use must be your own, or should contain source credits.* **Due Friday 3/7/14**

Get started.

APPENDIX C
UNIT 1 (DNA) PROJECT RUBRIC

DNA REPLICATION PROJECT RUBRIC 2014

Part I: DNA STRUCTURE		
Structure of nucleotides: (phosphate, sugar, 4 bases, correct bonding)	(4 points)	
Correct shape/structure of double helix: 20 base pairs shown (antiparallel strands, properly bonded and <i>twisted</i>)	(2 points) (3 points)	
Proper alignment and representation of 3'-5' strands: (sugar direction, labels correct, code correct)	(3 points)	
Part II: DNA REPLICATION		
Overview of the process (purpose, timing, outcome) <i>Short paragraph</i>	(4 points)	
4 enzymes shown properly	(4 points)	
Leading strand/lagging strand details	(2 points)	
Origins of replication / replication bubbles	(2 points)	
Explanation: importance of accuracy <i>Short paragraph / explanation</i> (DNA repair system, mutations, apoptosis)	(3 points)	
Neatness/attention to detail overall: 1 2 3	(3 points)	
Total:	30 points	
Comments:		

APPENDIX D

UNIT 2 (PROTEIN SYNTHESIS) TEACHER-GENERATED TEST (NON-
TREATMENT)

Protein Synthesis TEST
9Lilley Bio April 2014

Modified True/False

Indicate whether the sentence or statement is true or false. If false, change the identified word or phrase to make the sentence or statement true.

- ___ 1. Genes determine a person's eye color by coding for nitrogenous bases that affect eye color.

- ___ 2. If a nucleic acid contains uracil, it is DNA. _____
- ___ 3. The anticodon AGA is complementary to the codon TCT. _____
- ___ 4. A codon consists of four nucleotides. _____

Short Answer questions:

5. A *stop codon* on an mRNA molecule does not code for any _____.
6. How many codons are needed to specify three amino acids? _____
7. What are the three main parts of an RNA nucleotide? Please draw an RNA nucleotide here:
8. Explain what RNA polymerase does.
9. How do the amino acids get into "the proper order"?
10. Where are the master plans for "the proper order" of amino acids stored?
11. Where do we get the amino acids necessary to make our own proteins?

12. What **RNA** strand would be transcribed from the following DNA sequence?

T A T C G A C C A

13. Using the table below, what amino acids would be translated from this RNA sequence:

A U G C A C G U A

resulting amino acids: _____

		Second letter				
		U	C	A	G	
First letter	U	UUU UUC	UCU UCC UCA UCG	UAU UAC	UGU UGC	U C
		UUA UUG		UAA UAG	UGA UGG	A G
	C	CUU CUC CUA CUG	CCU CCC CCA CCG	CAU CAC	CGU CGC CGA CGG	U C A G
		CAA CAG		Arginine		
A	AUU AUC AUA	ACU ACC ACA ACG	AAU AAC	AGU AGC	U C	
	AUG		AAA AAG		AGA AGG	A G
G	GUU GUC GUA GUG	GCU GCC GCA GCG	GAU GAC	GGU GGC GGA GGG	U C A G	
	Valine		GAA GAG		Glycine	

USING SCIENCE SKILLS – use the diagram below to answer questions 14 – 18

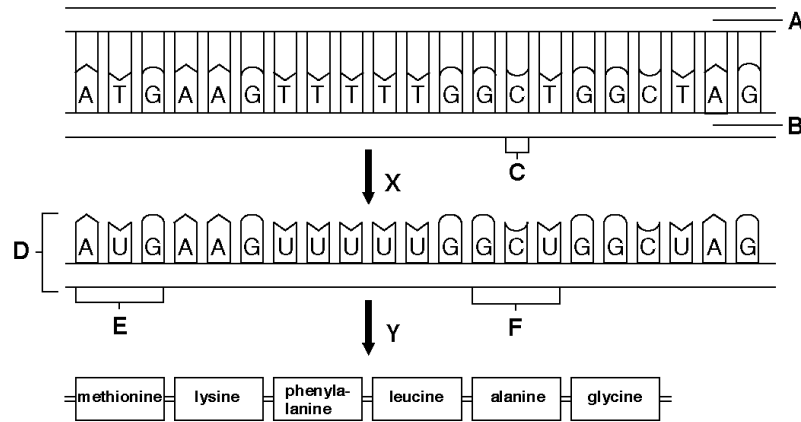


Figure 11-1

14. What is **structure E** in Figure 11-1? Why is it important?
15. What are **Strand A** and **Strand B** made of? How are they related?
16. Identify **structure F** in Figure 11-1. What does it code for?
17. What would happen to **structure F** in Figure 11-1 if **structure C** were deleted?
18. From which labeled structure in Figure 11-1 is **Strand D** made? (How is it assembled?)

Long answers: Please answer 3 out of 4 of these questions. You may omit ONE.

19. Describe the structure and function of **tRNA**.
20. Why must the mRNA be edited before translation? Explain.
21. What's the difference between your proteins and your neighbor's proteins?
22. Describe the effects that a mutation in DNA would have on the resulting protein.

APPENDIX E

UNIT 2 (PROTEIN SYNTHESIS) PROJECT GUIDELINES (TREATMENT)

April 2014 – PROTEIN SYNTHESIS – DNA to Protein PROJECT

*This project requires an **explanation** and **visual representation** of how DNA is used to code for proteins (including the details of transcription and translation). You will start with a sample piece of DNA (that you write) and show what protein that piece of DNA would code for.*

DETAILS: How the DNA molecule directs the synthesis of proteins (contains instructions for making them). Include the following:

1. You need to start with a DNA strand that is exactly 25 base pairs in length. You come up with the code, using any combination of A, T, C, and Gs.
2. Show and explain the process of TRANSCRIPTION (formation of mRNA), including the enzymes involved
3. Show the mRNA before editing, with proper details of RNA nucleotides
4. Show the editing process (get rid of the junk INTRONS)
5. Explain the role of tRNA at the ribosome; show and explain how amino acids are added. (You can't just have the amino acids magically appear. They should *scientifically* appear, with an explanation.)
6. You must end up with a polypeptide chain of exactly **5 different** amino acids.
7. You must use the correct *start* and *stop* codes. Look them up.
8. Explain the cause and effect of mutations.

You may work backwards or forwards (start with DNA code and find out what you get, or start with the amino acids you want, and work backwards) depending on how your brain wants to do it. Keep track of your work, use pictures, and show every step. You may show this electronically, with video or animation and narration, with a model, or in words and pictures, or any combination of those. *The slides, photos, and images you use must be your own, or should contain source credits.* **Due date TUESDAY April 8, 2014**
Get started.

APPENDIX F

UNIT 2 (PROTEIN SYNTHESIS) PROJECT RUBRIC

Protein Synthesis PROJECT Rubric

April 2014

Name:

This project requires an **explanation** and **visual representation** of how DNA is used to code for proteins (including the details of transcription and translation). You will start with a sample piece of DNA (that you write) and show what short protein that piece of DNA would code for.

DNA strand of 25 base pairs: Nucleotide detail: phosphate, sugar, 4 bases, correct bonding Double stranded 25 base pairs long	(8 points) 4 points 2 points 2 points	
Details of TRANSCRIPTION: Role of RNA polymerase shown Proper nucleotides used (A, U, C, G)	(5 points)	
mRNA EDITED/SPLICED correctly: Introns identified Exons pasted back together Proper number of nucleotides shown (18)	(5 points) 2 points 2 points 1 point	
Details of TRANSLATION: Role of tRNA ribosome P site and A site correct Start/Stop codons used 5 different amino acids properly <i>translated</i>	(8 points) 2 points 2 points 2 points 2 points	
Processes explained correctly: (transcription, editing, translation)	(3 points)	
Cause and effect of mutations:	(2 points)	
Neatness/attention to detail overall: 1 2 3	(3 points)	
Total:	34	

APPENDIX G
ATTITUDE SCALE

To be given before and after intervention

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

1. In general, rate your preparation for tests in this class

Very Unprepared Unprepared Prepared Very Prepared

2. Rate your sense of preparation after completing this project

Very Unprepared Unprepared Prepared Very Prepared

3. I feel that this **test** accurately assesses what I know

Strongly disagree Disagree Agree Strongly Agree

4. I feel that this **project** accurately assesses what I know

Strongly disagree Disagree Agree Strongly Agree

APPENDIX H
STUDENT QUESTIONNAIRE

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

1. How do you feel about projects that are assigned in place of tests?
2. When you have a choice, what kinds of projects do you prefer? (choose one)
video, poster, song, model, PowerPoint, oral presentation, other
3. About how much time did you spend preparing for this test?
4. About how much time did you spend completing this project?
5. Do you think the test accurately measured your understanding of DNA replication and protein synthesis?
6. During the project portion of this study, can you explain why you chose the project format that you did?
7. Do you feel that you are more in control of your grade on a test or on a project?
8. Do you feel that you were an active or passive participant during this process?
9. Did the “muddiest point” assessment technique help to guide you towards understanding the material during the test unit? If so, how?
10. Did the project rubric help to guide you towards completion of the project?
11. Do you think the scored project rubric accurately reflect your understanding of DNA replication and protein synthesis?

APPENDIX I
FORMATIVE ASSESSMENT INSTRUMENTS

During the instruction portion of each unit, I administered the “*Muddiest Point*” *Classroom Assessment Technique* to help students to articulate specific aspects of the unit they’re having a hard time understanding. The prompt distributed to students for the protein synthesis unit read as follows (and was the same as the prompt for the DNA unit except for the name of the topic):

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

After looking over the review sheet for protein synthesis, what part of the process is still confusing? (Or complete the sentence: The part of protein synthesis that's difficult for me to explain clearly is _____ .)