

UTILIZING RETRIEVAL PRACTICE AND NARRATIVE WRITING
TO REDUCE THE ACHIEVEMENT GAP IN HIGH SCHOOL
ANATOMY PHYSIOLOGY STUDENTS

by

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ABSTRACT

The researcher utilized retrieval practice and anxiety reducing techniques prior to assessment in an attempt to improve performance and narrow the achievement gap between students of color and their peers. In order to answer the question of whether “utilizing retrieval practice and narrative writing could reduce the achievement gap in high school anatomy physiology students”, baseline anxiety surveys, pre and post-assessment interviews, performance on assessment content covered by retrieval practice were collected. Data were analyzed both qualitatively and quantitatively, with results which suggested that students performed better on content that received the retrieval practice treatment. Data was inconclusive regarding the result of narrative writing on anxiety.

INTRODUCTION & BACKGROUND

I recently completed my sixth year teaching an honors anatomy physiology course at Berkeley High School, a diverse urban high school in Northern California. Berkeley High school is the only traditional high school within the Berkeley Unified School District with student enrollment for the past few years hovering at just over 3,000 9th-12th graders. According to 2018 data collected from the California Department of Education, 28% percent of our students qualified for free and reduced lunch in 2017 and 15% of them were current or re-designated English learners. Forty percent of our students identify as European American, 17% African American, 22% Latino, 8% Asian American, 11% two or more races with the remaining 10% Filipino, Pacific Islanders, Native American and non-reporting. While most of our students graduate, close to 90% in 2015, they are not all leaving Berkeley High equally prepared. Of our graduates there is a sizable disparity between European American and Asian American students and their African American and Latino classmates in meeting University of California and California State requirements. This gap in achievement is mirrored in student performance around the school and in the low numbers of African American and Latino students enrolled in the advanced placement classes with a reputation of rigor.

The 2018-2019 school year marks my seventh year teaching high school life science and my sixth year at Berkeley High School. My motivation to continue in this demanding field despite inadequate pay and a monumental workload is, and has always been, the students. The students of Berkeley High School are simply amazing. They are well informed, curious and passionate about everything from world events to supporting

the local teacher's union. Berkeley High School is a special place, we have a world class jazz program and for the last 50 years we have been home to the only high school African American studies department in the United States. Our diversity is much of what makes our school great, but it also comes with challenges.

During my six years at Berkeley High I have seen firsthand that like many urban districts we are consistently failing to meet the needs of our most vulnerable students. Most of my students are motivated and college bound, yet I observe a persistent achievement gap between my African American and Latino students and their European American and Asian American classmates. I had not observed any difference in effort in class or in time spent studying that would account for this phenomenon. As an educator this was both heartbreaking and incredibly frustrating. In the process of searching for a focus question I concluded that this capstone offered a unique opportunity to attempt to better meet the needs of my students. This experience in my own classroom led me to a specific research question: "will reducing testing anxiety through narrative writing and providing students with retrieval practice through regular formative assessment improve their test scores in my honors anatomy physiology course?" My attempt to narrow this gap had two components. First, I tried to address stereotype threat by reducing anxiety around test taking. Second, I tried to improve student performance on assessment by having students practice retrieval throughout each unit before they have a summative assessment. By looking at baseline anxiety through surveys and addressing test anxiety through narrative writing I attempted to reduce student anxiety and stereotype threat. I

also began integrating targeted retrieval practice into instruction time through formative daily assessment.

CONCEPTUAL FRAMEWORK

One of the current challenges in American education is the persistent achievement gap between African American and Latino students and their European American and Asian American classmates. African American and Latino students that participate in class, complete assignments and spend time reviewing for assessment still consistently score lower on high stakes summative assessment than their European American and Asian American counterparts. My research question involves “reducing testing anxiety through narrative writing and providing students with retrieval practice through regular formative assessment improve their test scores” is an attempt to narrow this gap. Stanford researchers, Sean Reardon, Demetra Kalogrides, and Kenneth Shores placed American racial/ethnic achievement gaps within school districts and metropolitan areas at 0.5 to 0.7 standard deviations (2018). The achievement gap is reflected in comparisons of African American and Latino students and their European American and Asian American classmates. Asian American students are grouped with European American students due to the fact that as a group they often outperform them. Jennifer Lee and Min Zhou point out in their 2017 paper that Asian American students comprise a fifth of Ivy League students although they make up only six percent of the American population. Dividing students like this can be problematic, and the concept of the model minority can be damaging to students. That being said, for the purposes of this paper I will align myself with previous research by looking at the achievement gap between African American

students and European American and Asian American students. By examining the body of research on test taking in general, and then placing specific focus on test anxiety and preparation, I hope to identify ways to better serve all student populations. Narrowing the degree by which their performance on summative assessment differs could go a long way toward closing the achievement gap.

African American and Latino students are particularly vulnerable to an academic stressor known as stereotype threat, a term coined by researchers Claude Steele and Joshua Aaronson in 1995. It refers to the perpetual risk of confirming negative stereotypes through one's performance, deeds or appearance. Steele, Aronson and Kruglanski looked at how stereotype threat negatively affected the performance of African American college students as compared to their European American classmates and concluded that for Black student test takers, stereotype threat significantly reduced their test scores (1995). According to Cohen, Garcia, Apfel and Master (2006), African American students experience higher levels of stress and psychological threat in academic environments than nonminority students, due primarily to negative stereotypes about the intelligence of their race. Stereotype threat creates a vulnerability in an academic setting that could be contributing to the achievement gap I have observed in my own classroom.

Appel & Kronberger (2012), believed that the way to reduce stereotype threat was to give students a better way to cope. They suggested that reducing test anxiety is paramount to allowing all students to demonstrate knowledge. According to Mavilidi, Hoogerheide and Paas (2014), allowing students an opportunity to review test questions

before beginning an assessment reduced their anxiety and increased their performance.

Mavilidi et al. (2014), concluded that if you reduced the working memory being occupied by the anxiety the student will have more available working memory to complete the task.

There are various techniques and strategies that researchers have used in an attempt to increase student performance. Strategies that have been shown to reduce anxiety, as well as those that improve test performance will be most likely to have an effect on the achievement gap. One technique that has been used to lower the anxiety of students in a high-stakes testing situation is writing about their anxiety (Ramirez & Beilock, 2011). This study found that anxious students who were asked to write expressively about their test anxiety before taking a test performed better on the test than anxious students who did not write about their concerns. Ramirez and Bleilock also observed that expressive writing about anxiety was especially useful for students with test anxiety (2011). It may also be possible to affect student anxiety levels by increasing their confidence in a task. Stankov, Lee, Luo and Hogan(2011) suggest that how confident a student is can actually be a comparable if not better predictor of academic achievement than how anxious they are.

An approach to improving performance on summative assessment that can also increase confidence is preparation. Douglas Fischer and Nancy Frey (2017) point out that while overtly teaching students study skills has gone out of vogue, that doesn't mean it's not important. Finding an effective way to study the content could improve student performance on a test and help them help them learn content more efficiently. A strategy

that supports students in studying new material would be beneficial to both target and nontarget populations. Retrieval practice or repeated exposure to test questions may be the answer. Roediger & Butler found that retrieval practice produced greater long-term retention than studying alone, they defined retrieval practice as the retrieval of information from memory (2011). Testing can also be used as a way of acquiring or learning the content as well. Earlier work from Karpicke and Roediger asserted that students could also benefit from testing themselves while they are learning, because the act of retrieving the information leads to increased retention (2007). In a comparison between retrieval practice and an elaborative studying technique like concept mapping, Jeffrey Karpicke and Janell Blunt found that undergraduate science students who utilized retrieval specific mechanisms by quizzing themselves after a study session, outperformed students who created a concept map after studying the material or simply studied the material alone (2011).

Eliciting retrieval practice from students can be a challenge, as they are more likely to use testing as a way of identifying what they have already learned and can recall instead of using it to form content knowledge. In addition, they will often begin to exclude content from the testing process that they perceive as acquired and thus lose the benefit of long-term retention (Karpicke & Roediger, 2007).

One possible solution is repeated testing over the time that the content is being delivered. This can be achieved by a series of quizzes before a final retention test (Wiklund-Hornqvist, Jonsson & Nyberg, 2014), or through repeated in class practice using an online game format (Iwamoto, Taitano & Vuong, 2017). In both cases the

testing cycle happens during instructional time, thus preventing the student tendency to allocate less study time to content they perceive as acquired. This is important because there is some evidence that students who stop studying items they can recall have less long-term retention (Karpicke & Roediger, 2007).

Another option for eliciting retrieval of content items would be to have the students generate multiple choice questions as a form of revision of material. Providing medical students in a biochemistry course who are preparing for assessment with a stem or key word and a list of distractors and asking them to write a multiple-choice question reduced the cognitive burden but still required students to retrieve information about the content (Bobby, Z., Radhika, M. R., Nandeesha, H., Balasubramanian, A., Perna, S., Archana, N. and Thippeswamy, D.N., 2012).

Because the experience of anxiety and fear of failure is likely a major contributor to the achievement gap (Cohen et al., 2006; Steele et al., 1995) an ideal way to support student achievement would be to reduce that fear and anxiety. Students who have high levels of anxiety perform lower on tests due to allocation of working memory but having them write expressively about their anxiety and look over the test before they begin can lower their anxiety and improve their performance (Mavilidi et al., 2014; Ramirez & Bleilock, 2011). It stands to reason that reducing anxiety in students of color is a way to reduce or counteract stereotype threat (Appel & Kronberger, 2012). The method of instruction and the type of tasks that students are being asked to perform can also affect student performance. Students who participate in retrieval practice end up with greater gains in both the short and long-term retention than students who do not (Karpicke &

Roediger, 2007; Karpicke & Blunt, 2011; Roediger & Butler, 2011). Eliciting this practice can be achieved by repeated testing or quizzing of content (Wiklund-Hornqvist et al., 2014; Iwamoto et al., 2017), as well as the generation of multiple-choice questions by the students themselves (Bobby et al., 2012). The true value of both of these approaches is that although they are designed to be helpful to African American and Latino students in particular, they should be just as beneficial to the rest of class.

METHODOLOGY

This research is an attempt to answer the question “can retrieval practice and anxiety reduction techniques narrow the achievement gap in an 11th and 12th grade anatomy physiology course?”. The subjects of this study, 81 11th and 12th grade students in my high school honors anatomy physiology class, participated in surveys, brief writing tasks and targeted retrieval practice. Although all students in attendance completed surveys and answered prompts on assessment, only half of the class were asked to write about their anxiety. All students in attendance received all retrieval practice treatments so as to guarantee that all students had equal access to learning tools. The research methodology for this project was approved by the Montana State University Review Board and found compliant in its work with human subjects (Appendix A).

In order to answer whether or not retrieval practice and anxiety reduction can affect the achievement gap I utilized a variety of data collection methods, which can be found in the Triangulation Matrix (Table 1).

Table 1
Triangulation Matrix of Methods

	Data Source 1	Data Source 2	Data Source 3
Anxiety reduction and student performance	School anxiety survey: Fall 2018	Preparedness Pre and Post-Likert Survey: Spring 2019	
Retrieval practice and student performance	Test scores on target questions, Test scores on non-target questions: Spring 2019	Test Preparation Preference Survey: Spring 2019	Short Answer Prompt for Test Preference 2019

To best answer my research question, I began by addressing two sub-questions. The first sub-question, “could utilizing anxiety reducing techniques reduce the anxiety associated with stereotype threat and improve student performance on assessment?” was addressed by utilizing student surveys and a narrative writing treatment. Students completed a self-assessment of anxiety as a student and a test taker. This survey was used to find a baseline of student anxiety. On the day of the assessment all students were asked to assess their anxiety, and then half of them will complete a brief writing task to narrate their anxiety. The other half of students also assessed their anxiety but the writing task they complete was not directly related. After completing the writing all students took the test. After the test they re-assessed their anxiety level using a survey. The pre and post-test anxiety surveys will be compared between the treatment group and the control.

The second sub question, “will use of techniques that elicit retrieval practice of content improve student performance on assessment?”, was addressed by introducing a retrieval practice component during class time wherein students were asked to practice specific target content from an upcoming assessment. Test results were then used to

compare student performance on the target content versus the non-target content.

Students were also interviewed regarding their preference for different study techniques in an attempt to see if they recognized the value of retrieval practice.

The treatment for this study had three components. The first two focused on anxiety assessment and reduction, while the third focused on content acquisition through retrieval practice. Methodologies that could potentially narrow the achievement gap for students of color are also beneficial to rest of the population. Reducing test anxiety and increasing content retention has the potential to help every student find increase success in a science classroom. Finding ways to reduce test anxiety also has the potential to reduce or negate stereotype threat and thus is of paramount importance for students of color. Another straightforward way to lower anxiety is to have students write about their feelings of worry and anxiety as it pertains to the testing situation (Ramirez & Beilock, 2011). This was attempted by utilizing surveys and writing exercises to access and reduce test anxiety followed by in-class retrieval practice designed to boost student performance on a summative assessment.

Content delivery along with the structure of class and study time can also have a profound effect on student performance. Giving the students repeated small quizzes either in a paper format (Wiklund-Hornqvist et al., 2014), or a Kahoot™ during class time (Iwamoto et al., 2017) could potentially show marked improvements in retention of science content for all students. Utilizing the digital platform Plickers™ I provided a way to reinforce retrieval. This treatment was given to target content while purposely excluding other content within the same unit to see if student recall was improved in a

higher stakes summative testing situation. Target content was then compared to non-target in summative testing results to identify any discrepancy.

Testing and School Anxiety Survey

The first treatment, which will be implemented as a pre-assessment of student anxiety, was given in mid-December of 2018. The Testing and School Anxiety Survey (Appendix B), is a baseline survey on anxiety around school and testing which will be useful in order to measure student anxiety and compare the anxiety rates of students of color to their European American and Asian American counterparts. This assessment is intended to assess a student's level of anxiety around school and student identity. The survey uses a Likert scale wherein *4=Always*, *3=Often*, *2=Sometimes*, *1=Rarely*. By using the mean for data analysis of the results I will be able to get a quantitative look at how my students self-assess their anxiety around school and how my two demographics compare. Many students experience some stress about assessment, so I included survey questions that covered both physical and emotion stress responses in hopes to identify students who are experiencing an undue amount of stress. This data was intended to help me pinpoint which students are feeling unusually high levels of anxiety so I could determine whether or not my students of color were experiencing higher levels of anxiety, which could potentially be attributed to stereotype threat.

Test Anxiety Writing Prompt

The second treatment had two parts, the first of which asked the students to complete a brief narrative writing immediately prior to taking a unit test (Appendix C). This treatment took place as part of the muscular system unit test in mid-February of

2019. The test was presented in two versions. Version 1 had a writing prompt that asked students “What are you worried about going into this test”, while Version II had a prompt that read “What would you have done to prepare if you had more time?” Versions were identical in every other way. Students received a version based on where they were seated, which had been randomly selected prior to the test. Having the students write about their emotional state prior to the assessment was designed to alleviate some of the anxiety they may have had around the test. However, in order to have a basis of comparison I created a control group where students still wrote, but not specifically about anxiety. The narrative writing prompt (Appendix C) appeared on the first page of the test, after a survey that asked them to rate their level of preparedness for the assessment. After a few minutes of writing they took the main portion of the test. Upon completion of the assessment all students repeated the survey rating their preparedness. The ratings of preparedness can be used to assess confidence in the material. By comparing any change in their confidence I hoped to identify any correlation in increased confidence levels after the writing prompt that could suggest a reduction in anxiety. Using narrative prompts in this way also enabled me to continue to track if my racial and ethnic achievement gap maps to high anxiety and lower confidence levels in students of color.

Confidence in Content Knowledge Survey

The second part of the treatment was a self-assessment of confidence in content knowledge that asked students to predict their level of preparedness. (Appendix C) This appeared as a pre and post-survey question on the muscular unit test. It utilized a Likert scale wherein *4=Very prepared, 3=Prepared, 2=Some-what prepared and 1=Not*

prepared. I will be analyzing the data by looking at the changes in confidence before and after the test across the control and treatment group. By having students self-assess their level of preparation I also hope to encourage some metacognition on the part of the students. It will help me to clarify which student are anxious, which are ill prepared, and which are both.

The final short answer prompt dealt with specifics around test preparation preference. “What helped you prepare for the test?” was designed to elicit which preparation techniques each student found effective. This could potentially inform on their feelings about my third treatment. These answers were analyzed to see which type of practice students found most useful and if retrieval practice was rated as a useful test preparation technique or not.

Retrieval Practice with Plickers™

I began to implement regular retrieval practice during the muscle unit as preparation for the unit test. This practice was in the form of warm ups that targeted specific muscles. By utilizing the platform Plickers™(Plickers.com) I was be able to quickly and easily provide students with a formative assessment on the prior day’s material. Plickers™ is a real time formative assessment program that allows students to participate in low stakes retrieval practice and receive instant feedback. The Plickers™ website allows instructors to format a question with multiple choice answers which are then projected on the board. Plickers™ provides a set of 40 unique geometric images that instructors can print on card stock and distribute to the class. The cards (Appendix D) are keyed to specific students which allows the instructor to track participation and accuracy

of individuals as well as the class overall. The cards are large, and capable of indicating an A, B, C or D answer depending on the way the student orients it. Students choose their answer and hold up the card in that orientation while the teacher instantly collects data by using a smart phone camera to scan the classroom. The correct answer is then projected on the board without revealing to the rest of the class individual accuracy. The teacher can see individual choices both in their personal device in real time, and in reports that are available later.

The target muscles covered in the Plickers™ practice were some of the same muscles that students were required to identify on the February muscle unit test. By choosing specific muscles to exclude from the practice it was possible to see if the retrieval practice had any effect on content retention for the unit test. All of the muscles that students were required to know were covered in classwork and homework. Throughout the unit the new content was reviewed using various methods, such as hands on labs, and review worksheets. Students also had access to Quizlet™, an online flashcard platform, but I did not require or supervise their use of it.

Muscle Unit Test

The final piece of data was the unit test (Appendix E), given in February. For the anxiety portion of my research I looked at how the anxious students performed on the assessment versus their less anxious counterparts. This was done by comparing the results of the anxiety survey with the test results. I looked at whether my African American students are more or less anxious than their peers, as well as attempted to make any achievement gap visible. It was also possible to identify any correlation between how

prepared students felt and their test scores, in order to determine if the students who felt prepared performed better.

The test data was also important in examining the results of the retrieval practice. Determining the effect of the retrieval practice entailed a comparison of student performance on target questions content covered in the Plickers™ practice to non-target test questions that were not covered in that manner. This was achieved by looking at student performance on specific questions and comparing it to what was covered with Plickers™ practice.

DATA AND ANALYSIS

In order to answer whether or not retrieval practice and anxiety reduction can affect the achievement gap I utilized a variety of data collection methods. The quantitative data collection instruments designed to measure and affect anxiety levels included the School Anxiety Survey and the Preparedness Pre and Post-Likert survey. The effect of retrieval practice on student performance was measured both quantitatively and qualitatively. The quantitative measurements were achieved through test scores and the Test Preparation Preference Survey and qualitatively through the short answer prompt for test preparation preference.

The School Anxiety survey was given to all three of my anatomy physiology classes. Of a total of 81 students 70 completed the survey. Results were analyzed by finding the mean for each student's responses to assign a numerical value to their overall anxiety level. Using these means I made a histogram to show the frequencies of the different levels of anxiety for all the participants. These frequencies were then converted

to a percentage so the data could be compared across the different N values and groups (Figure 1). When African American and Latino students ($N=23$), were disaggregated from their European American and Asian American counterparts ($N=47$) the data showed 4% of African American and Latino students reported being highly anxious, while only 2% of European American and Asian American students reported the same. Reporting “some anxiety” occurred more frequently in European American and Asian American students (17%) than it did for African American and Latino (13%). The majority of all students reported having low anxiety, with African American at 57% and my European American and Asian American students at 45%. European American and Asian American students averaged “little to no anxiety” slightly more often than African American students at 28% compared to 36%.

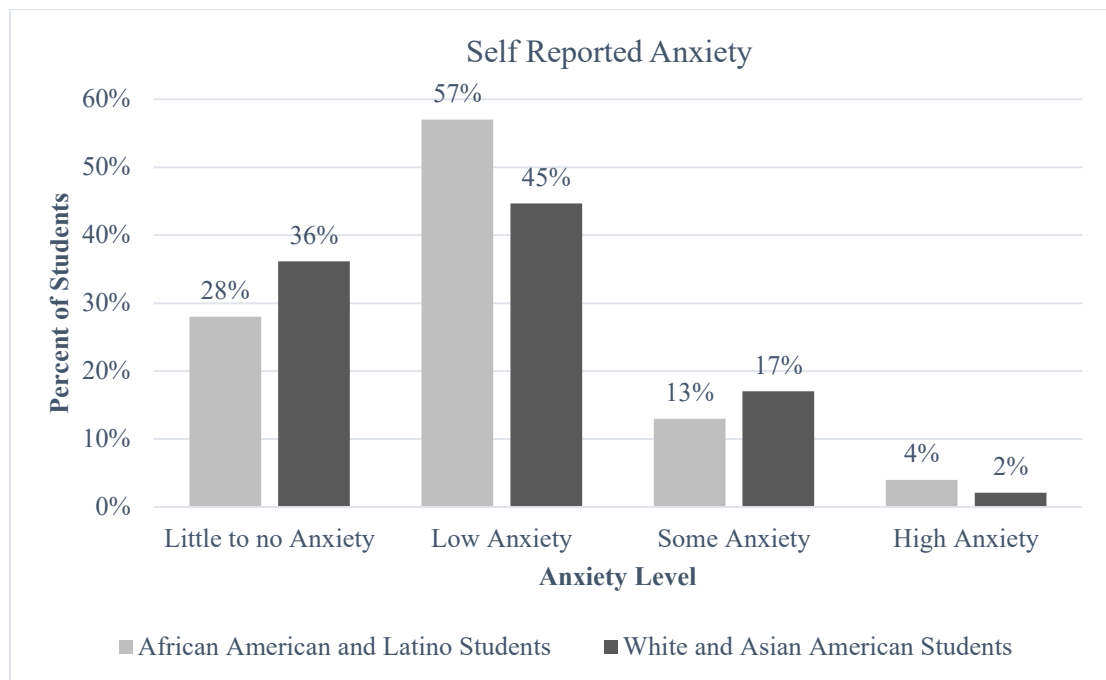


Figure 1. Comparison of self-reported anxiety in honors anatomy students (African American and Latino students, $N=23$; European American and Asian American students, $N=47$).

While the survey data showed slightly higher rates of students of color in the “high anxiety” category, these students also appeared at higher rates in the “some anxiety” category. It is not significant enough of a difference between students of color and their European American and Asian American classmates to say that one group of students is markedly more anxious than the other.

When the means for student responses were analyzed using a paired t-test this data was found to have a very high p-value of 0.85. This indicates that the data is not strong evidence for higher anxiety levels in either population. Students in general had low buy in on this survey as compared to their participation in other interview and survey data. It is possible that all students are hesitant to classify themselves as anxious or that they self-report lower anxiety on a written survey. It is also certainly possible that neither of these groups are particularly anxious about school and testing.

Student confidence levels in their preparation for the unit test were measured using a Likert scale survey. The survey responses for African American and Latino students were divided into two groups, the treatment group, and the control group. The treatment group included students who had written about their anxiety and the control group had not. The control and treatment group were then compared for gains and losses in confidence from the pre-survey to the post-survey (Figure 2.) The statistical significance was proven with an equal variance t-test which resulted in p-value of 0.04. This indicates that we can have some confidence in the results and that they are likely to be reproducible. Students in the treatment group who wrote about their anxiety felt more confidence in their preparation 59% of the time as compared to the control who felt more

confident only 17% of the time. Many students in both groups, 75% of the control and 29% of the treatment, reported the same confidence level both before and after the test. Some students experienced a reduction in confidence after they completed the test, 8% of the control group and 12% of the treatment group rated themselves lower in their post-test survey than they did in the pre-test survey. This could be due to overconfidence in the pre-test followed by the realization that the student was less prepared than they initially reported once the test was complete.

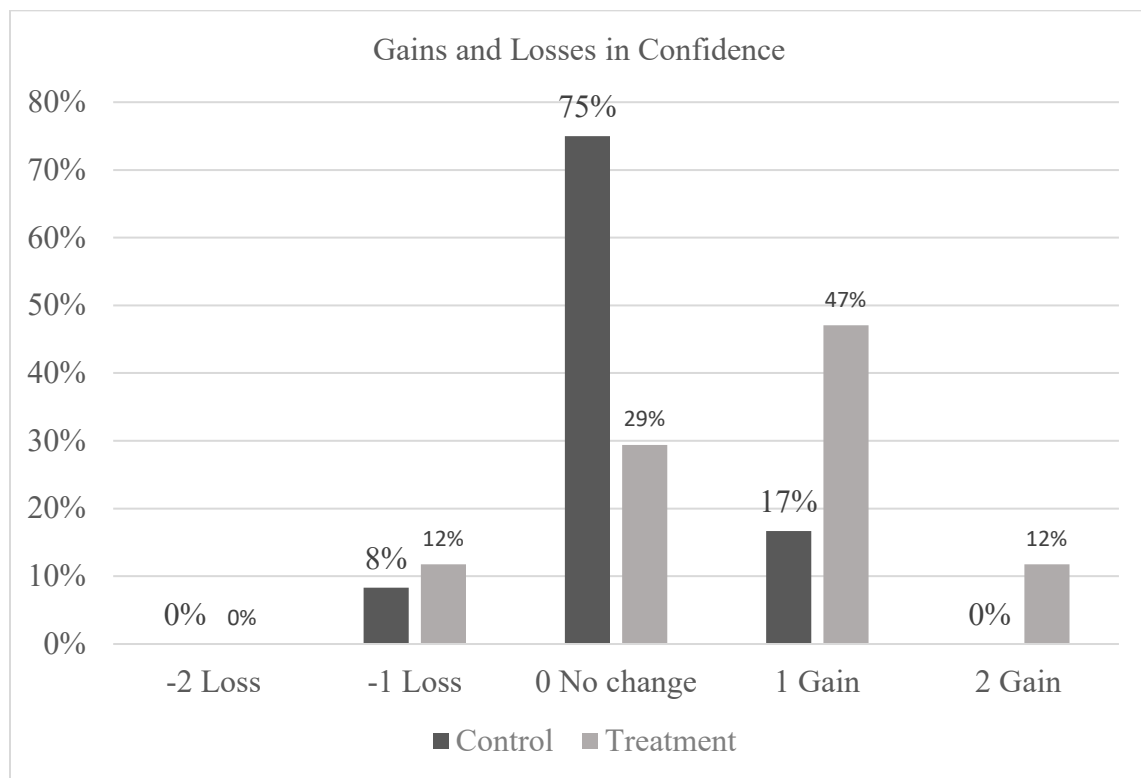


Figure 2. Gains and losses in confidence for African American and Latino students. Control, (N=12); Treatment, (N=17).

The survey responses for European American and Asian American students were processed in the same way with the differences between the control and the treatment

group charted in terms of gains and losses in confidence between the pre and post-survey (Figure 3.) Analysis with an equal variance t-test resulted in a p-value of 0.03. This disproves the null hypothesis and suggests that the results are reproducible. The majority of the European American and Asian American students in both the control and treatment groups did not have any gains or losses in confidence between the pre and post assessment. Twenty-five percent of the treatment group gained confidence in their post-survey, while 46% of the control group gained confidence. Many more students in the treatment group, 22%, suffered losses than the control, 5%. After comparing the data from Figures 2 and Figure 3 it appears that African American and Latino students received more of a benefit from the anxiety writing treatment than their European American and Asian American classmates.

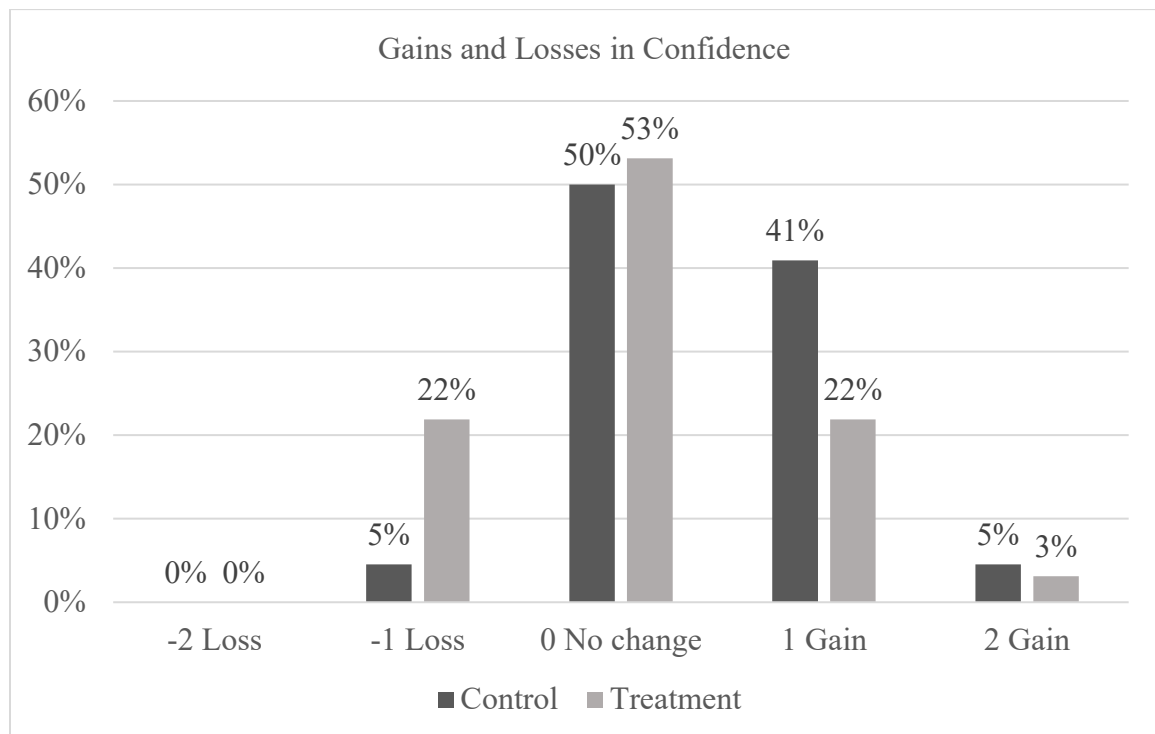


Figure 3. Gains and losses in confidence for European American and Asian American students. Control, (N=22; Treatment, (N=32).

The retrieval practice data compares student performance on target questions that were covered during the Plickers™ retrieval practice to questions that were not. Their Muscle Unit Test had ten target questions and 22 non-target questions that involved naming specific muscles. I took the percent of target questions that African American and Latino students answered correctly and then compared it to the percent of non-target questions that were answered correctly (Figure 4). These values were tested for validity using a paired t-test which at a p-value of 1.95×10^{-7} disproves the null hypothesis and provides a high degree of confidence.

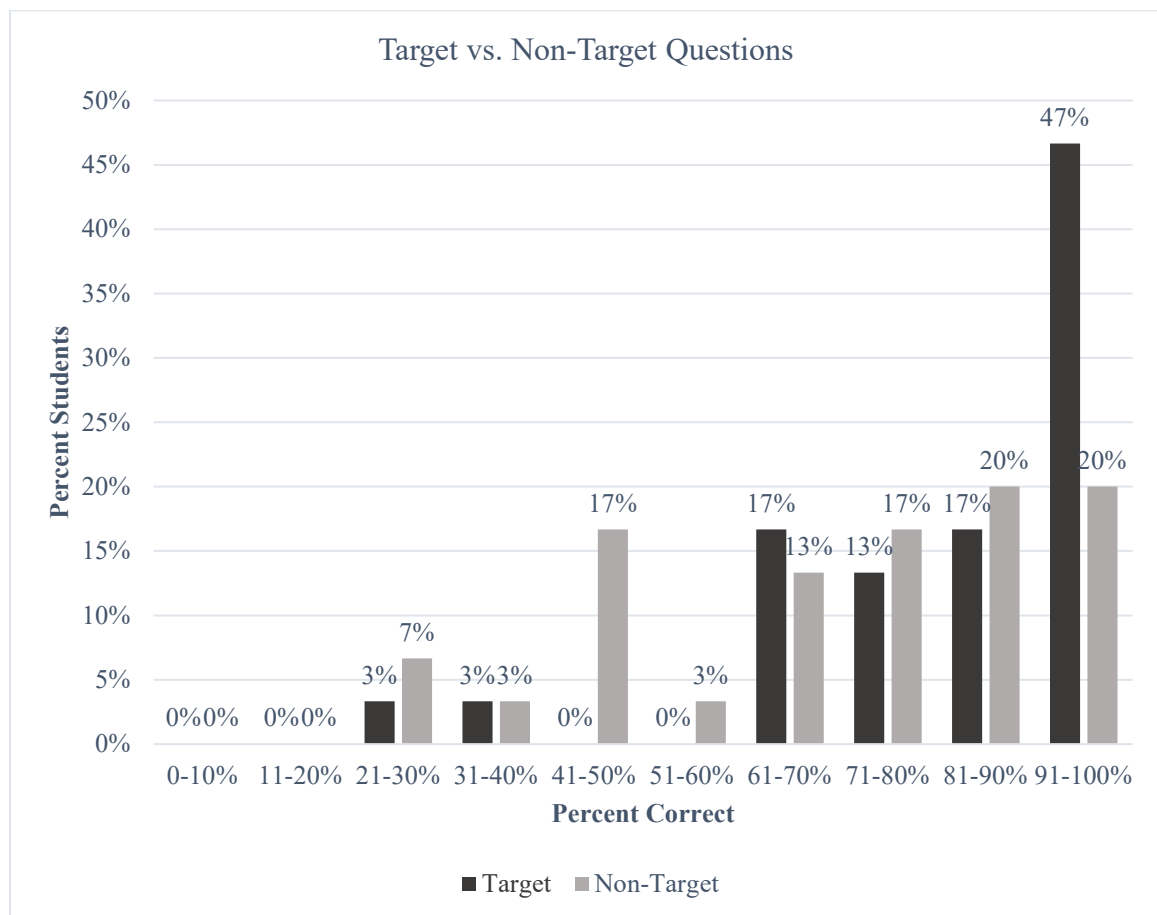


Figure 4. African American and Latino student performance on Target vs. Non-Target questions, ($N=30$).

Students of color ($N=30$) performed better on the target questions at the high end of performance. While only 20% of these students got 91-100% of the non-target questions correct, 47% got 91-100% of the target questions right. In all other ranges the students got the target questions correct less often than the non-target. The data seems to suggest that students performed better overall on the target questions, with 64% of them getting 81% or more of the questions correct. Only 40% of students got 81% or more of the non-target questions correct.

The same protocol used to compare target to non-target question performance for students of color was then applied to the rest of the class ($N=47$). Figure 5 shows European American and Asian American student performance target questions versus the non-target questions. A paired t-test was run on the data and resulted in a p-value of 1.23×10^{-8} which provides a high level of confidence in the results.

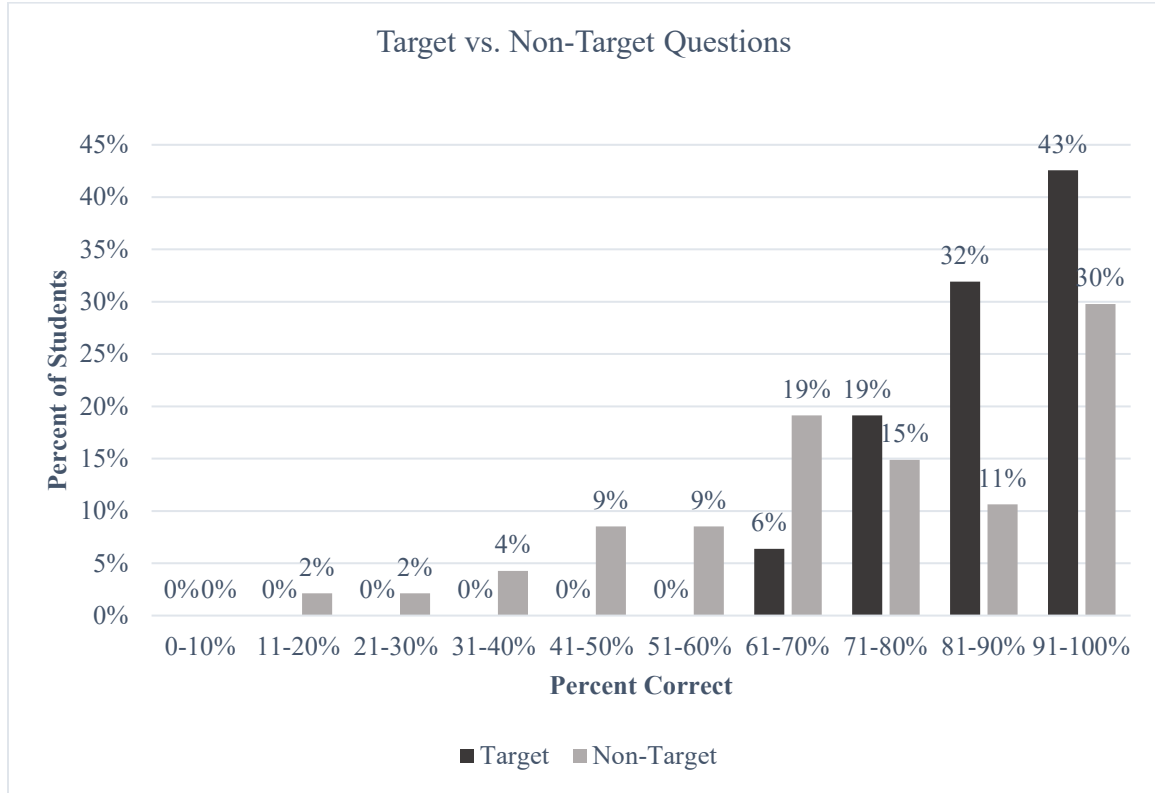


Figure 5. European American and Asian American student performance on target vs. non-target questions, ($N=47$).

It is clear that European American and Asian American students also performed better overall on the target questions. Ninety-four percent of students answered 71% or more of the target questions correctly while only 56% of students answered 71% or more of the non-target questions correctly. If you consider the fact that all of the rest of the students scored higher on the target questions these numbers make sense. Of the remaining students, none of them scored less than 60% on the target questions while 26% of them scored less than 60% on non-target questions.

Comparing Figures 2 and 3, suggests that the majority of students from both groups performed better on the target questions. Forty-seven percent of African American and Latino students and 43% of European American and Asian American students scored

in 91-100% range on the target questions. Only 20% and 30% of students, respectively, scored in the same range on the non-target questions. Ninety-four percent of African American and Latino students and 100% of European American and Asian American students got more than 61% of the target questions correct. Seventy-five percent of European American and Asian American students scored above 61% on the non-target questions which is similar to the results for the African American and Latino students, which showed 70% of students scoring 61% or more on non-target questions.

For the final data point, I interviewed students with written questions at the end of the unit test in order to find which type of test preparation they identified as being the most helpful($N=74$). They were asked to write a brief response stating their choice and explaining why they chose it. Some students also wrote about test preparation strategies they did not find useful. I took all of the student responses and created a histogram to find the frequency of preference for each type of review and then converted these into percentages (Figure 6).

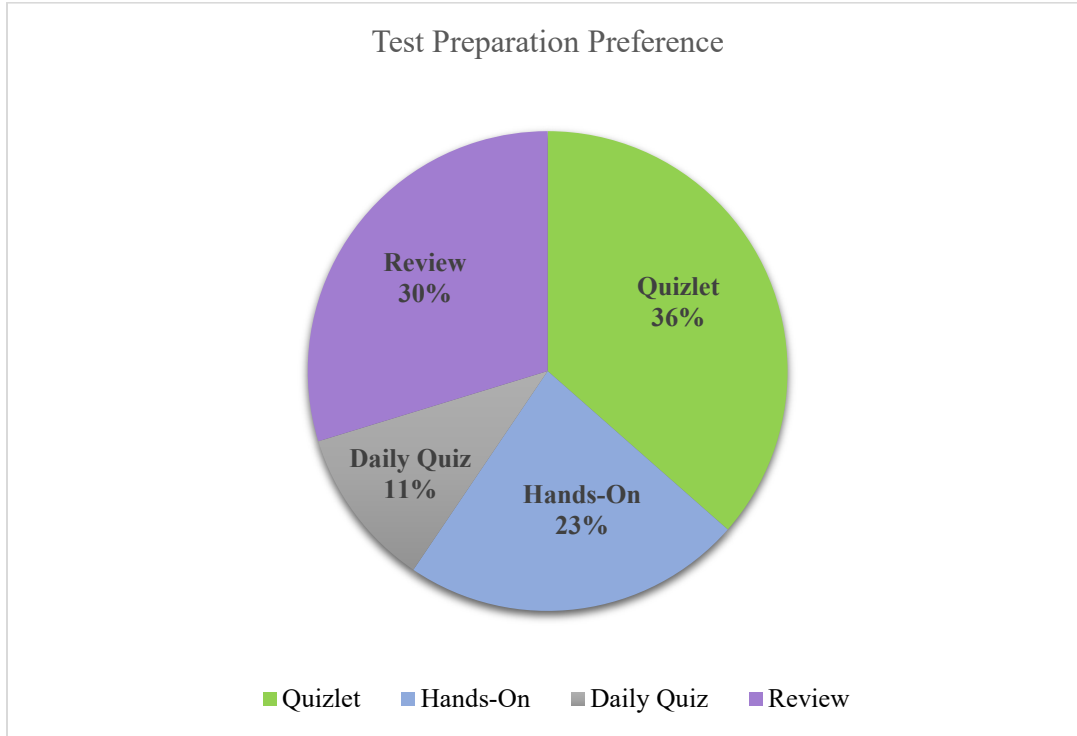


Figure 6. Student preference for test preparation, ($N=74$).

Students clearly preferred Quizlet™, with 36% listing it as their primary method of test preparation. Coming in a close second was the Review, with 30% of students listing it as their favorite review tool. The review is a handout I created for them to review material the day before the test. It included definitions, diagrams and questions. Twenty-three percent of students found the “Hands-On” activity, where they built individual muscles out of clay on a model skeleton, to be the most useful. Only 11% of students found the “Daily Quiz”, which is how I presented the Plickers™ retrieval practice, to be valuable test preparation.

Many of the students who preferred Quizlet™ cited convenience as one of the reasons they found it so useful. One student said, “Quizlets are the most helpful, we can study on the go.” Other students found that the way Quizlet™ presented the information

in flashcard format supported their retention of the material. “Quizlet helped me study the most because I find it easier to flip through and look at information over and over again until I have it memorized.” Students also found that Quizlet™ was “good for cramming” and useful as a last-minute study tool. It is telling that a majority of students polled described the most passive of the review techniques to be the most useful.

The second largest group of students queried found the test review to be the most helpful. The test review was provided to students the day before the test and class time was provided to complete it. Students particularly enjoyed the diagrams and the thoroughness of the review, stating, “The [review] helped me because you can see each muscle in relation to the others” and “visualizing the muscles with the diagram helped.” Of the students who preferred the review as test preparation a majority of them found the practice labeling especially helpful. This was very close to what they were asked to do on the test. A few students found the thoroughness of the review to be overwhelming, describing it as “far too much to try and memorize.”

The hands-on activity in this unit was the clay muscle lab. The students who found this activity useful seemed to really enjoy the hands-on nature of it. One student wrote, “Making the muscles from clay was especially helpful. And I practiced by pointing to the muscles and naming them.” Another wrote that the lab helped her because she could “see very clearly where each muscle was.” An issue with the clay muscle lab was that students tended to divide the labor within their groups which meant that every student did not build every muscle. Students cited this flaw in their critique of the activity, stating that, “the clay lab only helped me for the muscles I built.”

Very few students found the daily quiz or Plickers™ retrieval practice to be a valuable review strategy. Those that did had very little to say about it other than statements like, “I feel like the daily quiz helped me.” Even though the daily quiz is low stakes and they profess to enjoy Plickers™, it is possible that they dislike the idea of daily quiz because they dislike assessment. Their failure to see this as an effective study technique is particularly interesting in light of the results of the retrieval practice treatment I discuss earlier in this section, which show how effective it can be.

With the exception of their dislike of the daily quiz, students seemed to rank their preferences by how much work they had to put into them. They loved Quizlet™, which was the most passive of the of the practices, was unsupervised and was not required. Their second choice, the review assignment, required a little more work. Many students completed it within a 55-minute class period and it was possible to pool resources and to work as a group of two to three students. The hands-on activity, the clay muscle lab, consisted of four days of building individual muscles on a plastic skeleton. While some students found this activity helpful, many found it difficult and/or confusing to scale up three dimensional muscles from two dimensional models. The daily quiz appears to be the exception to this trend, however there was an expectation that students study new muscles each night in order to prepare, which could be interpreted as extra work on the students’ part.

INTERPRETATION AND CONCLUSION

The data did not support any difference in baseline anxiety for African American and Latino students and their European American and Asian American classmates. It was

neither statistically significant or visible with simple graph comparison. This is not to say that African American and Latino students do not suffer from school related anxiety and stereotype threat, just that this data does not show it. Minority students have been shown to suffer from very high rates of academic performance related stress and anxiety (Cohen et al 2006). It is possible that a different set of survey questions or a different tool all together could yield very different results.

The data was mixed on whether or not narrative writing about anxiety can reduce anxiety in a testing situation. For African American and Latino students it seemed to make a difference. Fifty-nine percent of these students showed an increase of confidence after writing about their anxiety. Research has shown that confidence could play a similar role in performance as other self-belief measures like self-concept, self-efficacy and anxiety (Stankov et al 2011). It is possible that some of that increase in confidence could be attributed to students under-estimating their level of preparation and then realizing after the assessment that they knew more than they thought. For European American and Asian American students the results were quite different. It seems that the act of writing about their anxiety had less of an effect and that the majority of students maintained the same level of confidence in their preparation for the assessment whether or not they wrote about their anxiety. In this group we saw more students in the treatment group that lost confidence between the pre and post-survey. This could be due to overconfidence on the part of the student as to their level of preparation, although it is strange that 22% of students in the treatment group lost confidence while only 3% of students in the control group did. I suppose it could be argued that they overestimated their level of preparation

and then lost confidence over the course of the test as compared to the control group which either accurately assessed or under estimated their level of preparedness. Asking students to self-assess their confidence around content knowledge is bound to create unpredictable and even contradictory results. Having confidence in your level of preparation is based on a very personal metric that can vary from individual to individual.

While my attempt to measure the overall anxiety levels of my students was not successful, I believe the results of the anxiety writing treatment were sufficient to suggest that it would be good practice to include this strategy in the future. It takes very little time to have students write about how they are feeling before a test. If there is even the slightest chance that it could help increase their confidence going into an assessment it is time well spent.

The data on retrieval practice, on the other hand, seems quite conclusive. Students did better on the questions that were covered with the Plickers™ daily quizzes. The results were striking in both groups, with 43% of European American and Asian American students and 47% of African American and Latino students getting between 91-100% of the target questions correct. Only 20% of African American and Latino students and 30% of European American and Asian American students did as well with the non-target questions. These results are further supported by previous research on the efficacy of retrieval practice that has shown an increase in content retention in students who utilize it (Roediger & Butler 2011). Ninety-four percent of African American and Latino students and 100% of European American and Asian American students got 61% or more of the target questions correct. This is compared to 70 and 75% respectively for

the non-target questions. It is clear from these results that the retrieval practice was beneficial to all students as a strategy for learning and memorizing content.

Student preference suggests that they did not see the value in the Plickers™ retrieval practice. The tool that they valued most, at 36% of students, was Quizlet™ the online flashcard system. Quizlet™ is in fact a type of retrieval practice, although the flashcard sets they used were not designed to mimic the assessment in the same way the Plickers™ daily quiz was. Students preferred test preparation techniques that required the least amount of labor on their part, like Quizlet™, over techniques that required more independent work like the clay muscle lab and the Plickers™ daily quiz.

Building more retrieval practice into my Honors Anatomy Physiology course is of paramount importance now that I know how effective it is. Expanding the amount of content covered in this way and increasing the amount of time students spend using technology that elicits this practice has the potential to be a game changer for some students. I will continue to utilize Plickers™ to this end, but I also believe that it should be possible to leverage the students' love of Quizlet™. By controlling the flash card sets they can access and logging their time online, I can expand their access to effective retrieval practice.

VALUE

Completing a capstone project while teaching full time comes with a specific set of challenges. As teachers we are beholden to the school year and the content that needs to be covered within certain time frames. As researchers we need more time to refine our methodology and redesign our approaches to get more complete data. We are left with

doing the best we can given the circumstances. In a perfect world I would have liked to repeat the anxiety writing and the pre and post-confidence surveys, and then looked at the retrieval practice results on another assessment or two.

After analyzing the data, I have become curious about how the anxiety writing treatment affects test performance as well as how accurate students were at predicting their level of test preparation. Due to the manner in which I collected this data it is simply not possible to do this without repeating the treatment.

I am also curious to see if there is any correlation between student preference for specific test preparation and test scores. Do the students who see value in the Plickers™ retrieval practice perform better than students who prefer Quizlet™? I would like to do a preference comparison between African American students and European American and Asian American students, in order to see if one groups prefers a certain type of practice.

The results of the Plickers™ retrieval practice on student performance has been the most exciting part of the capstone project. This inquiry cycle has offered a great deal of insight into how students learn in my class. Over the years, I have observed that some students intuitively know how to study. They seem to know that retrieval practice is the key to success and when they study they make flashcards and quiz themselves and mimic an assessment situation. Where they learn this set of skills is unclear to me. Perhaps from family, or peers, or a combination of both? It doesn't seem to stick as well when it comes from teachers, at least at the high school level. Students who don't intuitively do this often tell me that their classmates are better students than them, or just smarter. They cannot see the invisible work that is happening outside of class when their peers go home

to “study”. By moving the retrieval practice into the classroom it could be possible to even the playing field, to give the students who don’t really understand how to study access to these tools. It is possible that this could be particularly beneficial for my African American and Latino students, many of whom have already or are about to surpass their parents’ education level. This type of practice in class could actually affect the achievement gap and also be sustainable for teachers.

I was so excited about this retrieval practice data that I shared it with my department in the hopes that other science teachers might find a way to integrate it into their courses. As teachers we are aware of strategies and pedagogy that we know to be beneficial to students. The problem is often in implementing it. We are so limited in time both in the classroom and outside it that we can’t always use best practices with our students. Retrieval practice using online resources like Plickers™ is fast, easy and does not require students to use an electronic device. And most importantly it works. It works for African American and Latino students, it works for European American and Asian American students. I believe that easy to implement and accessible strategies like this are how we can continue to address the achievement gap in American classrooms.

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APPENDICES

APPENDIX A
HUMAN RESEARCH EXEMPTION



INSTITUTIONAL REVIEW BOARD
For the Protection of Human Subjects
FWA 00000165

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MEMORANDUM

TO: Johannah Bearg and Marcy Reuer
FROM: Mark Quinn, Chair *Mark Quinn*
DATE: November 26, 2018
RE: "Can Retrieval Practice and Anxiety Reduction Techniques Reduce the Achievement Gap in an 11th/12th Grade High School Anatomy Physiology Course?" [JB112618-EX]

The above research, described in your submission of November 25, 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:

- X (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- X (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- _____ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- _____ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- _____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- _____ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

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

APPENDIX B
TESTING AND SCHOOL ANXIETY SURVEY

Testing & School Anxiety Survey

1. When I take a test my heart beats faster, my palms get sweaty and/or I feel sick to my stomach
A. Always B. Often C. Sometimes D. Rarely
2. When I take a test I can't concentrate on the test questions because my mind is racing
A. Always B. Often C. Sometimes D. Rarely
3. When I take a test I get mixed up when bubbling my answers on a bubble sheet
A. Always B. Often C. Sometimes D. Rarely
4. When I take a test I answer test questions incorrectly even when I know the correct answer
A. Always B. Often C. Sometimes D. Rarely
5. When I take a test my mind goes blank
A. Always B. Often C. Sometimes D. Rarely
6. When I take a test I read the same question over and over and still can't understand it
A. Always B. Often C. Sometimes D. Rarely
7. When I take a test I feel like I can't breathe
A. Always B. Often C. Sometimes D. Rarely
8. When I take a test I have nightmares about tests and/or can't sleep for worrying about them
A. Always B. Often C. Sometimes D. Rarely
9. When I take a test I spend time outside of class worrying about test
A. Always B. Often C. Sometimes D. Rarely
10. When I take a test I feel like everyone else in the class knows the answers
A. Always B. Often C. Sometimes D. Rarely
11. When I take a test I feel like I am going to fail
A. Always B. Often C. Sometimes D. Rarely

12. When I take a test I feel like I studied “wrong”

- A. Always B. Often C. Sometimes D. Rarely

13. Stress about school keeps me awake at night

- A. Always B. Often C. Sometimes D. Rarely

14. I think of myself as a good student

- A. Always B. Often C. Sometimes D. Rarely

APPENDIX C
ANXIETY WRITING PROMPT
CONFIDENCE IN CONTENT KNOWLEDGE

Name: _____

Muscle ID V1

1. Predict your level of preparedness for this test by choosing one of the following (Bubble)
- a. Very prepared b. Prepared c. Somewhat prepared d. Not prepared
2. What are you worried about going into this test? Write 2-3 sentences. (Do not bubble)

Student ID							
	0	0	0	0	0	0	0
	1	1	1	1	1	1	1
	2	2	2	2	2	2	2
	3	3	3	3	3	3	3
	4	4	4	4	4	4	4
	5	5	5	5	5	5	5
	6	6	6	6	6	6	6
	7	7	7	7	7	7	7
	8	8	8	8	8	8	8
9	9	9	9	9	9	9	

Assessment Version: 1 2

1	A	B	C	D	E
2	A	B	C	D	E
3	A	B	C	D	E
4	A	B	C	D	E
5	A	B	C	D	E
6	A	B	C	D	E
7	A	B	C	D	E
8	A	B	C	D	E
9	A	B	C	D	E
10	A	B	C	D	E
11	A	B	C	D	E
12	A	B	C	D	E
13	A	B	C	D	E
14	A	B	C	D	E
15	A	B	C	D	E

in this area

do not mark

Page 1

Name: _____

Muscle ID V2

- Predict your level of preparedness for this test by choosing one of the following (Bubble)
 - Very prepared
 - Prepared
 - Somewhat prepared
 - Not prepared
- What would you have done to prepare if you had more time? Write 2-3 sentences. (Do not bubble)



ID: AcZ4jL9wkoEIQNu0Aft1s4AAwAAAAA

Fill In Like This: ● Not Like This: ☒ ☑ ○

Student ID

0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9



Assessment Version: 1 2



1	A	B	C	D	E
2	A	B	C	D	E
3	A	B	C	D	E
4	A	B	C	D	E
5	A	B	C	D	E
6	A	B	C	D	E
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8	A	B	C	D	E
9	A	B	C	D	E
10	A	B	C	D	E
11	A	B	C	D	E
12	A	B	C	D	E
13	A	B	C	D	E
14	A	B	C	D	E
15	A	B	C	D	E



do not mark
in this area



Name: _____

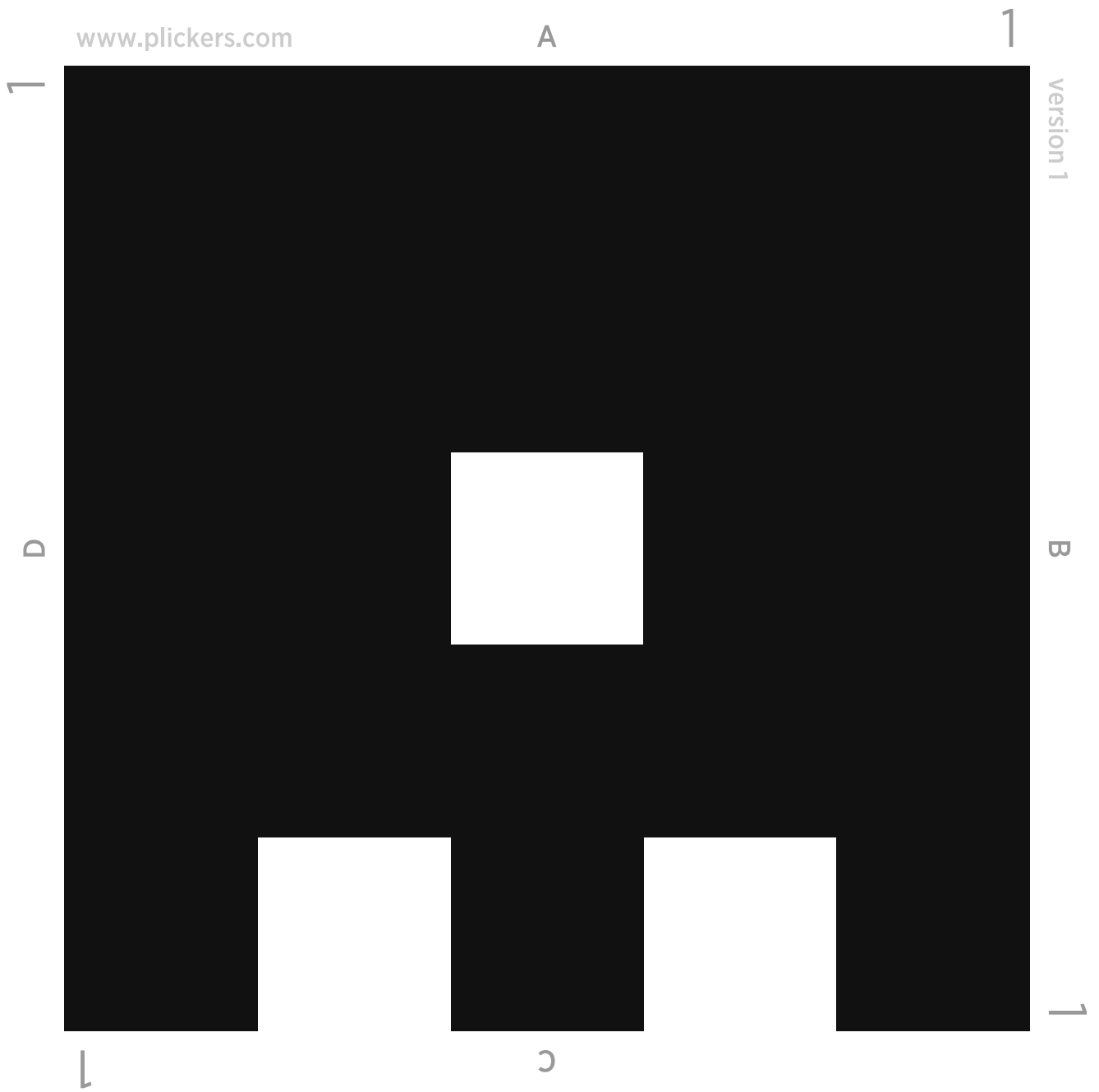
44

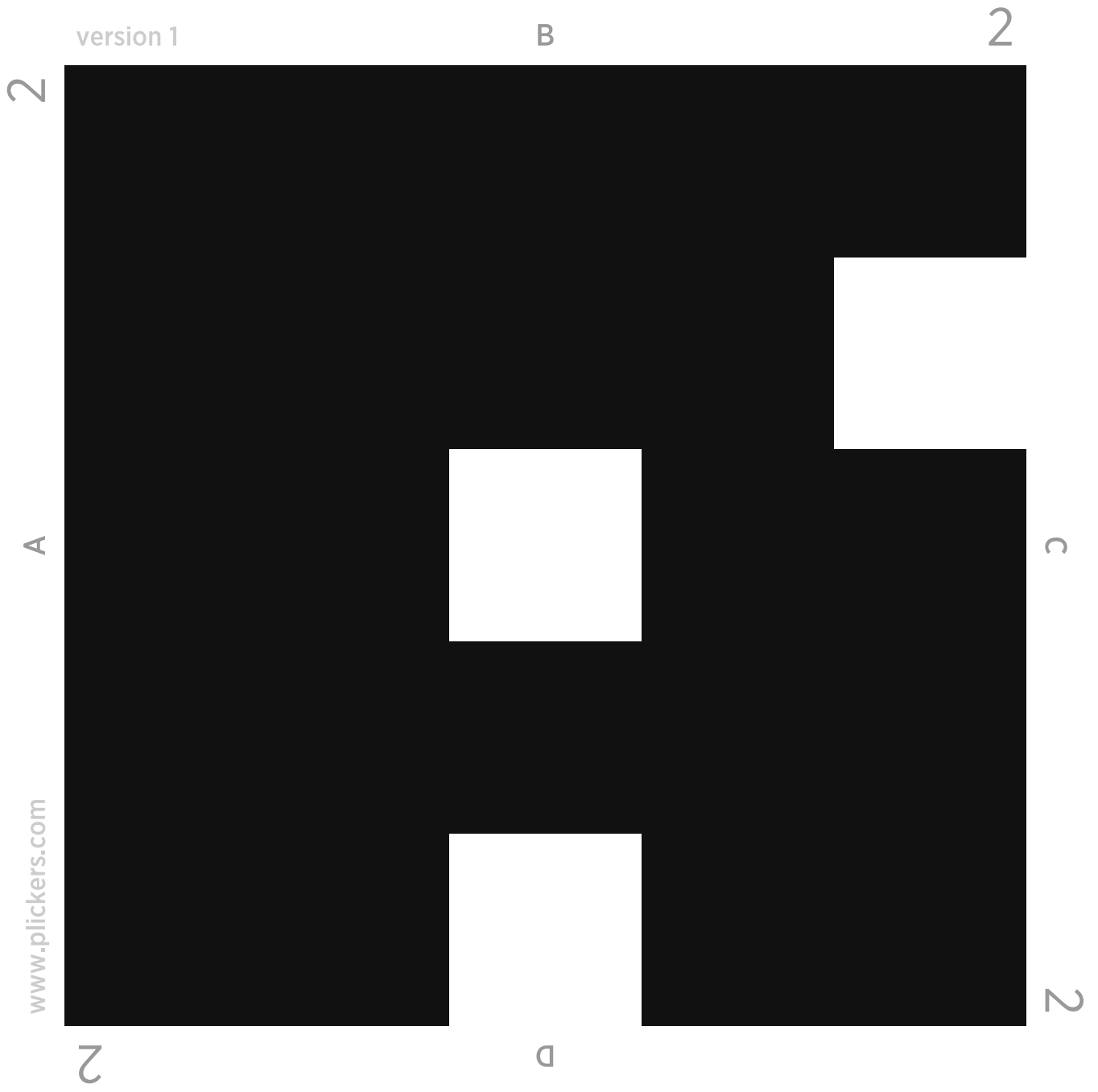
15. Now that you have taken the test rate how prepared you feel you actually were

- a. Very prepared b. Prepared c. Somewhat prepared d. Not prepared

What helped you prepare for the test (what worked?) Write 2-3 sentences. (do not bubble)

APPENDIX D
PLICKERS™ CARDS





APPENDIX E
MUSCLE TEST

Chapter 11 “Muscle ID”

Reflection:

1. See bubble sheet.
2. See bubble sheet.

Multiple Choice: (answer on bubble sheet)

3. Which of the following is NOT a muscle of mastication (chewing)?
 - A) masseter
 - B) temporalis
 - C) zygomaticus
 - D) soleus
 - E) buccinator
4. The "kissing muscle" that circles the lips is the
 - A) zygomaticus.
 - B) orbicularis oculi.
 - C) buccinator.
 - D) orbicularis oris.
 - E) temporalis.
5. Which of the following does NOT move the shoulder?
 - A) pectoralis major
 - B) rhomboids
 - C) serratus anterior
 - D) rectus abdominis
 - E) trapezius
6. The muscle directly deep to the gastrocnemius is the
 - A) biceps femoris.
 - B) soleus.
 - C) sartorius.
 - D) fibularis longus.
 - E) tibialis anterior.
7. Miles, a trumpet player, asks you which muscles he should develop in order to be a better trumpeter. What would you tell him? (You don't need to know how to play the trumpet to answer this question)
 - A) the occipitofrontalis and buccinator
 - B) the buccinator and orbicularis oris
 - C) the orbicularis oris and trapezius
 - D) the risorius and orbicularis oculi



8. Muscles comprising the quadriceps group include the
- A) rectus femoris, vastus intermedius, vastus lateralis, and vastus medialis.
 - B) rectus femoris, tibialis anterior, soleus, and adductor longus.
 - C) peroneus, gastrocnemius, vastus intermedius, and rectus femoris.
 - D) iliopsoas, gracilis, adductor magnus, biceps femoris, and gracilis.
 - E) semitendinosus, biceps femoris, rectus femoris, and vastus medialis.
9. The _____ covers the anterior surface of the neck.
- A) platysma
 - B) epicranium
 - C) occipitofrontalis
 - D) orbicularis oris
 - E) buccinator

Matching: Match the function to the correct muscle (#s 8 - 12)

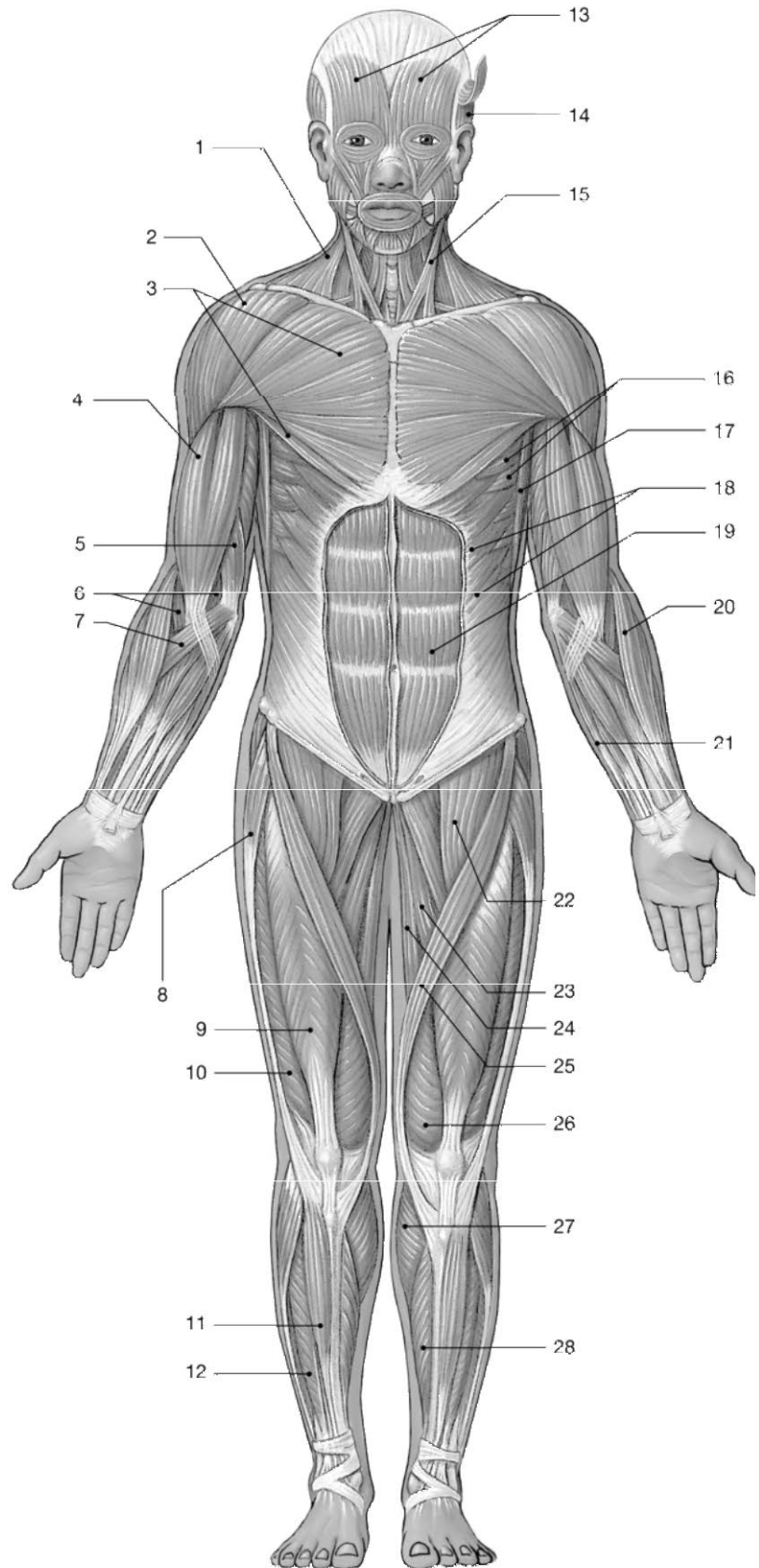
- | | |
|---------------------------------------|------------------------|
| 10. Turns face to the opposite side | A) risorius |
| 11. Closes eye | B) occipitofrontalis |
| 12. Closes mouth | C) sternocleidomastoid |
| 13. Draws the corners of the mouth up | D) orbicularis ori |
| 14. Raises eyebrows | E) orbicularis oculi |
15. Answer the question on your bubble sheet AFTER you complete the short answer section.

END OF MULTIPLE CHOICE SECTION

MUSCLE DIAGRAM: ANTERIOR VIEW

- 3 _____
- 15 _____
- 6 _____
- 13 _____
- 2 _____
- 7 _____
- 25 _____
- 4 _____
- 20 _____
- 14 _____
- 24 _____
- 11 _____
- 16 _____
- 19 _____
- 18 _____
- 26 _____
- 9 _____
- 10 _____

For muscle #s 9, 10 & 26, name
the muscle GROUP:



MUSCLE DIAGRAM: POSTERIOR VIEW

Short Answer: Name the muscles whose numbers appear below.

Use the word bank provided.

18 _____

1 _____

6 _____

13 _____

2 _____

14 _____

12 _____

15 _____

11 _____

10 _____

For muscle #s 10, 11 & 20, name
the muscle GROUP:

EXTRA CREDIT:

20 _____

3 _____

