THE USE OF WRITING PORTFOLIOS IN PLACE OF TRADITIONAL EXAMS IN HIGH SCHOOL BIOLOGY

by

Brian Joseph Theroux

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of

Master of Science

in

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ABSTRACT

The desire for metrics of student ability remains high even as emphasis changes from high-stakes, high-stress standardized assessments of content and memorization to procedural awareness and communication skills. This study investigated the effectiveness of writing portfolios in place of traditional exams. Classroom research checked for consistency between students of different incoming knowledge and ability levels, and for effects on student motivation and course engagement. Students' expression of core concept knowledge was assessed through writing portfolios in treatment groups and with short answer tests in comparison groups. Data collected from test scores, portfolios, surveys and teacher-student dialogues was triangulated using qualitative and quantitative analysis. Results suggested students' expression of core content knowledge and basic subject knowledge were equitable or improved, with notable alleviation of test grievances.

INTRODUCTION AND BACKGROUND

I have been teaching freshman biology at Delbarton School since 2005. Delbarton is an all-boys Catholic secondary school administered by the Benedictine monks of St. Mary’s Abbey in Morristown, New Jersey. One-hundred-thirty students enter Delbarton each year, from over 80 sending schools in suburban and urban settings (Diveny & Aucoin, 2016). Upon acceptance to Delbarton, incoming students complete a set of standardized assessments in order to establish a baseline metric of incoming aptitude across disciplines. One of these assessments is the science subject portion of the Stanford Achievement Test form-A task-1, which is similar in nature to the type of standardized assessment used as part of the college admissions process (D. Donovan, personal communication, March 2018).

Despite the utility of standardized assessments, there is a school-wide emphasis on recalibrating student performance expectations away from rote memorization and more towards synthesis and application of knowledge (Delbarton Program of Studies, 2018). Across disciplines at Delbarton, argumentation through reading and writing receives reinforcement as a foundational academic skill. Writing portfolios offer a potential way to assess skill in application and performance within a group of ninth-grade biology students. The additional benefits of synthesizing laboratory reports with routine in-class writing, in a reflective manner, makes writing portfolios an appealing assessment option.

In addition to engaging students in a college preparatory course curriculum, part of Delbarton’s mission is to build character in educating the whole person: mind, body, and spirit (Delbarton Mission Statement, 2018). In the context of modern life, this mission aligns strongly with digital citizenship. Within science courses, digital citizenship education often takes the form of identifying reliable sources of information and communicating with a global audience. Simultaneously, the development of skills to self-edit work and engage constructively with feedback fosters student's resilience (Diveny & Aucoin, 2016).

The pursuit of assessment strategies maintaining academic rigor while fostering resilience and digital citizenship lead to the creation of my focus statement: What is the effectiveness of using writing portfolios based on lab investigations and coursework in place of traditional exams? Classroom research also addressed two additional sub-questions:

1. Were effects of writing portfolios consistent across students of different incoming knowledge and ability levels?
2. How does the use of writing portfolios affect student motivation and engagement with the course?

CONCEPTUAL FRAMEWORK

The high-stakes and high-stress format of traditional testing is being scrutinized. Pressure placed on students to score high marks deters effort away from understanding material in depth in favor of memorization of information (Gibbs & Simpson, 2005). Teacher's time and effort spent on test prepping and student time spent scheming how to game the exam come at the expense of reflective thought and connecting content to personal experience and real life applications. Many standardized tests penalize diversity and creativity, and tempt cheating (Kamenetz, 2015). For all of these reasons, university science and engineering programs are reducing emphasis on standardized assessments of content knowledge, viewed as being of fleeting utility, in favor of demonstrations of more enduring thinking and communication skills (Deresiewicz, 2014).

The desire for metrics of student ability remains high even as emphasis changes from content and memorization to procedural awareness and communication skills. Employers look for indicators of performance based on skills of reading and writing (Cervetti & Pearson, 2012). Similar performance indicators are used by educational institutions, which have noted how humanities majors outperform biology majors on the MCAT medical school admission test (Deresiewicz, 2014). Coupled with this growing appreciation for the understanding accompanying use of language arts skills is the finding that coursework marks are a better predictor of long-term learning than exams. There is a desire for methods of assessment embedded within coursework and based on communicating understanding through writing. Assessment is the greatest single determinant of what and how students study (Gibbs & Simpson, 2005). This motivational power of assessment can direct students toward valuable outcomes.

The integration of content knowledge with science and engineering practices, particularly argumentation from evidence, is increasingly desirable in post-secondary education and modern life (NGSS, 2013). Scientifically literate citizens are expected to do more than recall information from a textbook, they must also be able to think like a scientist (Tyre, 2008). Specific subject material is more meaningful and actionable when it arises as part of instruction focused on how to methodically obtain and articulate scientific understanding (Deresiewicz, 2014). While students enjoy and learn from the applied nature of individual lab activities, they often struggle to articulate concepts linking concomitant labs. Students particularly struggle to communicate an understanding of connections in writing (Patterson, 2001). However, writing skills are essential to scientific communication (Tyre, 2008). Reading and writing constitute a large portion of scientists' regular activity, and should therefore be a significant component of science education (Cervetti & Pearson, 2012). The difficulty many students have with communicating in writing underscores the need for writing in the science classroom.

Reflecting and writing about sets of labs promotes understanding of crosscutting concepts and the nature of science. Self-reflection is particularly effective in science instruction when combined with mathematical reasoning and formulating generalized conclusions, two common components of written lab reports (Mayer & Hillman, 1996). Summary reflection also enables students to make connections between course content and their lives. Consistent revision of writing improves learning and confronts misconceptions (Jordan, 2004). Revision undertaken with feedback from teachers and peers generates engagement while focusing on effective communication of understanding (Gibbs & Simpson, 2005). Sustained practice with written scientific argumentation increases students' reasoning skills and ability to connect concepts (McNeill & Krajcil, 2009).

Providing students with a consistent writing strategy across the curriculum helps students express understanding in every content area, including science (Grymonpre & Solomon, 2012). The Framework for K-12 Science Education encourages teaching students to compose scientific arguments using a Claim-Evidence-Reasoning writing format (Reiser, Berland & Kenyon, 2012). The Assert-Support-Evidence writing method promoted by many English educators engages students with a process of explaining so a reader obtains a deeper understanding of the material (Lemov, Driggs & Woolway, 2016). Mnemonic differences aside, both writing strategies provide a structure allowing students to evaluate evidence within a coherent framework, in order to communicate arguments and understanding clearly (Deresiewicz, 2014). Scaffolding within frameworks such as Claim-Evidence-Reasoning and Assert-Support-Evidence prompts students to include support for scientific arguments, emphasizing the necessity of evidence (McNeill & Krajcil, 2009).

Writing portfolio assessments engage students in the process of reflecting on their understanding as they re-engage with coursework. Best-work portfolios include introductions to each entry and a cover letter presenting the collected entries to a defined audience (Mayer & Hillman, 1996). Students document their understanding of scientific content and the process of science through revised coursework and written justifications of how each entry represents their progressing knowledge of the topic (Adu-Gyamfi, Bosse & Faulconer, 2010). Reflective writing portfolios built around lab activities have potential to remedy some of the common grievances with traditional testing. They can help students engage in critical thought while finding a sense of purpose in the creative application of their studies to their lives (Deresiewicz, 2014).

METHODOLOGY

This investigation of writing portfolios as a replacement for traditional exams employed six data collection instruments: an SAT Science Subject test, multiple choice tests, short answer tests, writing portfolios, a Course Engagement Questionnaire, and notes on teacher-student dialogues. The research methodology and data collection instruments used in this study received an exemption from the Montana State University Institutional Review Board, and all relevant and appropriate guidelines for working with human subjects were followed (Appendix A). For this study, the treatment group consisted of classes given writing portfolio assessments, while classes in the non-treatment group took short answer test assessments.

In order to establish a baseline metric of incoming aptitude, all students completed the Stanford Achievement Test (SAT) form-A task-1 Science Subject test (Appendix B). The SAT Science Subject test consists of 40 multiple choice questions from a range of natural science disciplines. The SAT Science Subject test was administered simultaneously to all students before beginning the classroom research treatment (N=88). Scores from the SAT Science Subject test were analyzed using box and whisker plots. Comparisons of means and variance were used to determine the similarity of students in the pre-determined treatment and non-treatment groups. There were three non-treatment groups and three treatment groups of similar size. The smallest group contained 14 students, while the largest group had 17 students. Within treatment and non-treatment groups, SAT Science Subject scores were used to sort students into above-average and below-average categories for tracking the effect of treatment in relation to incoming ability.

The use of writing portfolios versus short answer tests was investigated throughout five units of instruction in freshman biology classes. The first unit covered biological principles, including the tools and techniques of biological study and an overview of the history of life on earth. The second unit covered biological chemistry, including reaction energies, polymer chemistry, and types of organic compounds found in live cells. The third unit was an introduction to cells, including parts of cells, types of cells, and cell reproduction via mitosis and meiosis. The fourth unit covered cell transport and the human immune system, including active and passive transport, non-specific immune responses, and actions of T cells and B cells as part of the specific immune response. The fifth unit covered microorganisms, including the biology of prokaryotes, human-bacteria interactions, and the structure and function of viruses. Each unit of instruction contained four guided laboratory investigations, for which students completed written lab reports.

At the completion of each unit of study, treatment and non-treatment groups took identical multiple choice tests (Appendix C). Multiple choice tests contained 20 multiple-choice questions focused on vocabulary terms and factual knowledge and were administered in the classroom using the Schoology class-website platform. Averages of multiple choice test scores between treatment and non-treatment groups were used as a metric of attainment of basic subject knowledge. Scores were analyzed using a t-test of averages.

In addition to multiple choice tests at the end of each unit of study, students in the non-treatment group also completed short answer tests (Appendix D). Short answer tests consisted of seven to ten questions, requiring several sentences to a paragraph for each answer. Questions on short answer tests came from laboratory investigations conducted in class, and reflected previously identified core concepts of the course. Students completed the short answer tests in the classroom using the Schoology class-website. Averages of short answer test scores served as metrics of core concept knowledge. The analysis of short answer test scores included t-tests of averages and f-test measures of standard deviation.

At the end of each unit of study, students in the treatment group completed writing portfolio assessments instead of short answer tests (Appendix E). Writing portfolio assessments consisted of revised and edited lab reports, and a summary cover letter. Lab reports were based on investigations conducted in class and reflected the previously identified core concepts of the course. Students completed writing portfolio assessments in class using Google Docs and submitted portfolios through the Schoology class-website. Average writing portfolio scores served as metrics of core concept knowledge. Analysis included t-tests of averages and f-test measures of standard deviation. Additionally, analysis of short answer test scores and writing portfolio scores for identical units of instruction between non-treatment and treatment groups included t-tests of averages and f-test measures of standard deviation.

A Course Engagement Questionnaire administered to all students in treatment and non-treatment groups measured students' self-perception of skills engagement, emotional engagement, participation engagement, and performance engagement (Appendix F). The Course Engagement Questionnaire required students to select responses for 23 questions using a Likert scale ranging from very characteristic of me, characteristic of me, moderately characteristic of me, and not really characteristic of me to not at all characteristic of me. Grouping of designated sets of questions on the Corse Engagement Questionnaire allowed for the analysis of the four engagement factor groups: skills engagement, emotional engagement, participation engagement, and performance engagement. Students completed the Course Engagement Questionnaire through Google Forms in class at the conclusion of the fifth unit of instruction. Graphical analysis of Course Engagement Questionnaire responses was done using stacked bar charts of engagement Factor groups. Further analysis was conducted using a comparison of means and Pearson Correlation tests for relationships to short answer, writing portfolio, and multiple choice test scores.

As part of the regular instructional practice at Delbarton, students in treatment and non-treatment groups were engaged in *conversatio* throughout the course of this study. *Conversatio* is a practice distinctive of Benedictine monastics, and involves the words or example of another person calling into question whether we are living a faith-filled life. In lieu of formal interviews, written reflections on teacher-student *conversatio* served as support for quantitative claims. Notes on *conversatio* student-teacher dialogues were analyzed to identify common themes and possible relations of perceived effects of quantified gains. Personal reflections served as an ongoing source of self-evaluation and were used to aid in identification of common themes and exemplars. The Data Triangulation Matrix summarizes the association of each data collection instrument to the primary and secondary research questions (Table 1).

Table 1
Data Triangulation Matrix

Primary Question:	What is the effectiveness of using writing portfolios in place of traditional exams?

Data Sources	Short Answer Test and Writing Portfolio Scores	Unit Multiple Choice Tests	Course Engagement Questionnaire	Notes on student/teacher dialogues
Secondary Question:	Were effects of writing portfolios consistent across students of different incoming ability?			
Data Sources	SAT Science Subject Test	Short Answer Test and Writing Portfolio Scores	Unit Multiple Choice Tests	Course Engagement Questionnaire
Secondary Question:	How does the use of writing portfolios affect student motivation and engagement with the course?			
Data Sources	Course Engagement Questionnaire	Notes on student/teacher dialogues	SAT Science Subject Test	

DATA AND ANALYSIS

A t-test of averages for writing portfolio scores compared to short-answer test scores for similar units of study showed significantly higher ($p < 0.05$) scores in 80% of writing portfolios (*N*=88). The variance of all writing portfolio scores within a unit was lower than short-answer scores of the same unit. An f-test of variance showed a significant decrease in variance ($p < 0.05$) in 40% of writing portfolios compared to short-answer exams within units of study (Figure 1). Students in the treatment group did not need statistical analysis to know results were significant to them, as one student put it "I'm horrible at taking tests, trying to cram and remember everything is hard for me, but with the portfolio I can space it out and check my work for mistakes." There was no significant difference in t-tests of averages ($p > 0.05$) between multiple-choice test scores of treatment and non-treatment groups on 80% of the five unit exams. However, several students expressed a greater sense of long-term retention of conceptual and factual knowledge, "I forget material that I learn for a test right after I take it" was a common refrain often followed up by a comment such as, "but the portfolio forces me to read and revise my writing to help me remember."

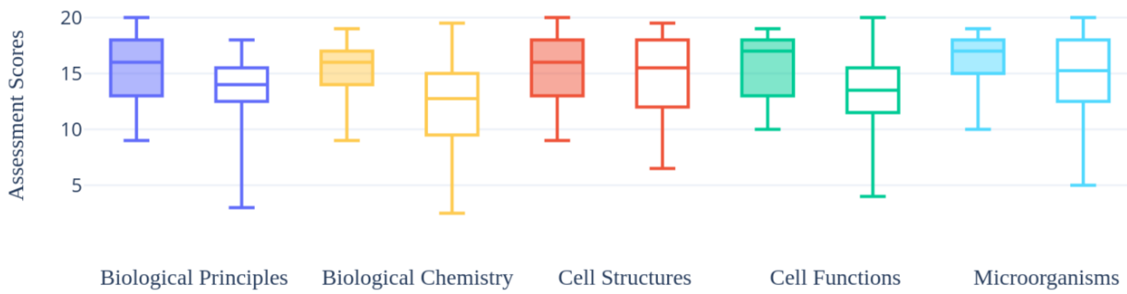


Figure 1. Comparison of writing portfolio scores (shaded) vs short answer test scores (open) by unit, (*N*=88).

T-tests of averages and f-tests of variance showed no significant difference between the SAT scores or distributions of treatment versus non-treatment groups, with p-values greater than 0.08 (Figure 2). Scores from the science subject portion of the SAT Test form-A task-1 were used to sort students into above-average SAT and below-average SAT categories for tracking the effect of treatment in relation to incoming ability. Students scoring 65% and above on the science subject portion of SAT were categorized as above-average SAT, while students scoring below 65% were categorized as below-average SAT.

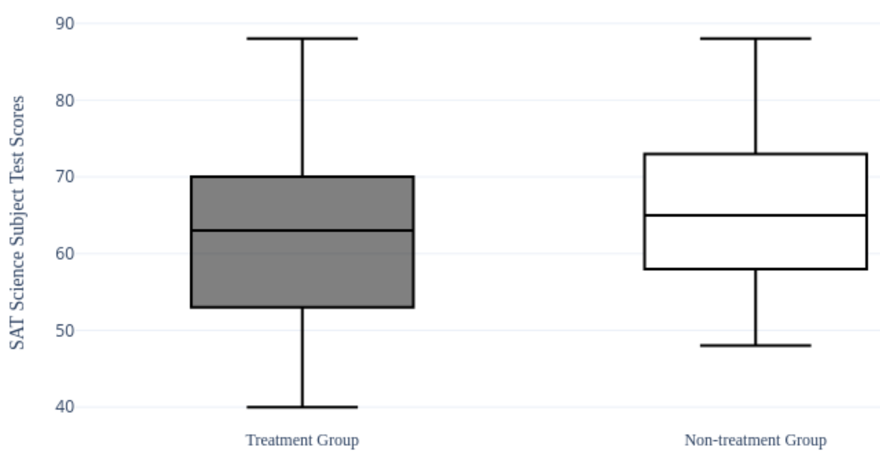


Figure 2. SAT science subject scores for treatment (shaded) and non-treatment (open) groups, (*N*=88).

Comparison of short-answer test and writing portfolio scores between treatment and non-treatment groups of below-average SAT students showed the same pattern as the overall groupings, with the treatment group having higher scores and less variance. There were two differences between the test scores of treatment and non-treatment groups of above-average SAT students. First, a t-test of averages for writing portfolio scores associated with short-answer test scores for similar units of study only showed significantly higher scores in 60% of writing portfolios ($p < 0.05$). Second, f-test of variance indicated no significant change in variance between writing portfolio and short-answer exam scores within any units of study ($p > 0.05$).

Comparison of above-average SAT and below-average SAT students in the non-treatment group using t-tests of averages showed significant differences on all test scores ($p < 0.05$), with no significant difference in variation of scores sown by f-tests of variation ($p > 0.05$) within units (Figure 3). The average score on all the tests was higher in the above-average SAT student group, though the range of scores within groups was similar. However, comparison between above-average SAT and below-average SAT students in the treatment group did not show significant differences on 40% of multiple-choice tests, and 60% of writing portfolios using t-tests of averages ($p < 0.05$). One student who noticed this pattern serendipitously said, “the portfolios have leveled playing field” on assessments. There was no significant difference in variation of test scores between above-average SAT and below-average SAT students within units.

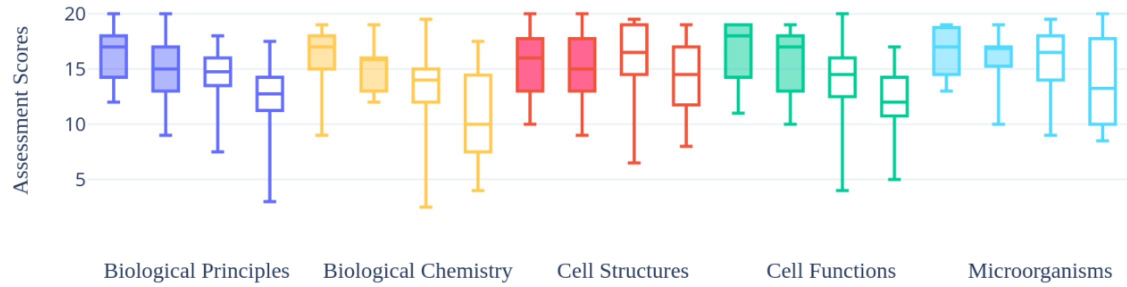


Figure 3. Comparison of writing portfolios (shaded) vs short answer (open) test scores by unit. Within each assessment group above-average SAT group is on left, and below-average SAT group is on right.

By the end of the fourth iteration, the practice of using short-answer tests or writing portfolios had become an established routine. In the fourth unit on cell functions there was a notable improvement in scores between treatment and non-treatment groups. The bottom-quartile score of 13 points for the below-average SAT students in the treatment group was higher than the median of 12 points for the below-average SAT students in the non-treatment group. Likewise, the median score of 17 points for below-average SAT students in the treatment group was higher than the first-quartile score of 16 points for the above-average SAT students in the non-treatment group. A similar pattern of score contrasts, with below-average SAT students showing superior performance, was observed in 80% of units of study when below-average SAT students work on writing portfolios was compared to non-treatment groups.

Student responses to the Course Engagement Questionnaire showed no significant difference between treatment and non-treatment students in any individual question or factor group (Figure 4). This statistical significance was supported by a Pearson's Chi-squared tests with values of $p > 0.05$. Students in non-treatment and treatment groups had the highest average Likert responses regarding self-perception of skills engagement, with a mean of 4.1 in both groups. Although the Course Engagement Questionnaire showed little difference in skills engagement, student *conversatio* offered a more nuanced perspective. Over 50% of students in the treatment group said they were "more confident in writing in science" and making connections between ideas. While the overall perception of skills engagement was unchanged, the specific skills engaged appear to have been different.

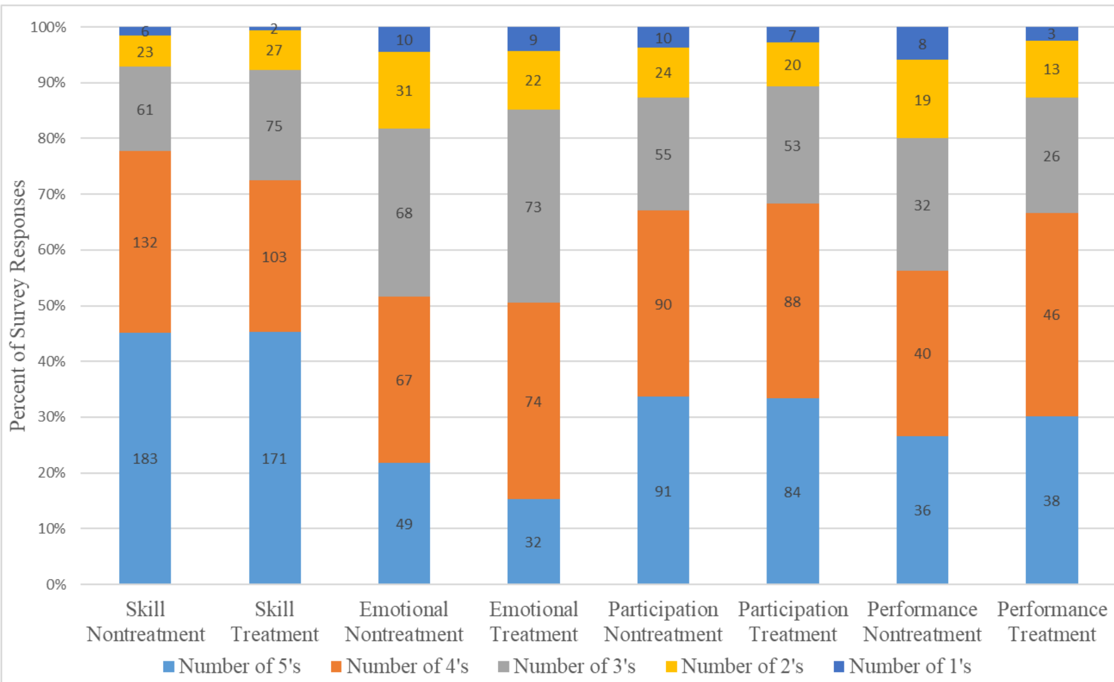


Figure 4. Course Engagement Questionnaire responses by Factor Groups, (*N*=88). Numbers in bars indicate total number of student responses in each category.

Students in both groups had the lowest average Likert responses in relation to emotional engagement, with a mean of 3.5 in both groups. There was no correlation between any Course Engagement Questionnaire factor group and multiple choice, short answer, writing portfolio or SAT test scores in either the treatment or non-treatment students. Detailed results for specific statistical tests, along with additional figures, are provided in the Supplemental Statistical Analysis (Appendix G).

INTERPRETATION AND CONCLUSION

Writing portfolios were an effective alternative to traditional exams. Student performance on measurements of conceptual understanding was higher on writing portfolios compared to short answer tests. Simultaneous measurements of content knowledge showed no drop in student performance, there were actually signs of increased performance in expressing understanding. Improved scores and loss of variance may be connected to and increased exertion of effort in writing portfolio assessments, as one student commented, “the portfolio is more interactive and time consuming, but I like this more than a test because there is less pressure.”

A comparison of student writing samples from short answer versus writing portfolios from the same unit can illustrate the difference in how connections between concepts were more developed in writing portfolios. After completing the unit on cell function, students in the treatment and comparison groups were asked to describe how macrophages use active transport to fulfill their role in the immune response. A sample response from a short-answer test taken by student in the below-average SAT group provided a superficial and unsubstantiated statement. A sample response from a writing portfolio submitted by a student in the below-average SAT group provides supporting explanations and makes connections to the additional concepts of endocytosis and exocytosis (Figure 5).

> Macrophages use active transport to produce antibodies in the body. Active transport needs energy to happen, so it uses that energy to produce antibodies.

Writing sample from short answer test taken by below-average SAT student.

> Macrophages use active transport when eating the pathogen and "spitting" out the antigens. When the macrophages ingest the pathogens they use the active transport called endocytosis. Endocytosis is when you take vesicles containing fluid or solid things into the cell. When the macrophage "spits" out the antigens (broken apart pathogen), it uses active transport called exocytosis. Exocytosis is when you push vesicles containing fluids and solids out of the cell.

Writing sample from writing portfolio submitted by below-average SAT student.

Figure 5. Comparison of conceptual connections in samples of student work.

Benefits of writing portfolios were more pronounced in students with below-average incoming standardized test scores. Traditional exams created greater disparities in performance between above-average and below-average students. Writing portfolios allowed students of below-average ranking to demonstrate a level of conceptual understanding more on par with their above-average peers. A common rational for this provided by students was the decrease of time pressures. One student noted, “I like having time to myself to figure out what is being said.” Another commented, “portfolios make me slow down and think about processes like mitosis and meiosis so I can think about concepts.” Portfolios may be an effective assessment tool because they encourage students to take the time they need to think about course material.

There were notable difference in the quality of writing and student’s ability to communicate a more developed understanding of concepts from the unit. After completing the cell function unit, students in the treatment and comparison groups were asked to describe how an intravenous injection of pure water might affect red blood cells of a hospital patient. A sample response from a short-answer test submitted by a student in the below-average SAT group asserts that it “would not be good”, but provided negligible support or explanation (Figure 6). The writing portfolio sample from a below-average SAT student provided more supporting details and explanation of reasoning. Other indicators of writing quality such as reduced use of the pronoun “it” are also noteworthy in a comparison of writing samples from short-answer and writing portfolios.

> Pure water would not be good if it was injected directly into the blood stream. The red blood cells would absorb too much of it and burst, which is very bad.

Writing sample from short answer test taken by below-average SAT student.

> If you were to be given an IV of pure water, then your red blood cells would be placed in a hypotonic environment where the concentration of water on the outside were to be greater than that inside cells. In this case, the water would osmosis into the cell and cause a condition known as cytolysis. When cytolysis occurs within a cell, such as your red blood cells in this situation, then your red blood cells would burst and cause fatal injury or even death.

Writing sample from writing portfolio submitted by below-average SAT student.

Figure 6. Comparison of quality of writing in samples of student work.

The Course Engagement Questionnaire indicated no change in student’s emotional engagement or participation engagement when writing portfolios were used in place of traditional tests. While it is encouraging that students did not balk at the increased workload of writing portfolios, the lack of increased emotional engagement with course content presents a potential for improvement. Would realigning writing portfolio expectations toward personal familiarity and real life applications increase student emotional engagement? More emotionally engaged context could allow for pairing the benefits of reduced stress and anxiety to with greater enjoyment.

VALUE

The pressure to score high marks on standardized tests such as the SAT or Advanced Placement exams can detract from understanding material in depth. Many science teachers lament the lack of hands on science practice in their courses, citing the lack of instructional time, with the implicit assumption being that lab investigations are less efficient at imparting factual knowledge than direct instruction. Yet the results of this classroom research indicate lab-based portfolios had a neutral effect on tests of factual knowledge. Furthermore, the hidden opportunity cost of time spent prepping and scheming for tests could be more effectively spent on thought, reflection, and written expressions of understanding.

High school students struggle to articulate connections between concepts from separate activities within the same unit, or between units. Short answer test questions are often considered in strict isolation, while writing portfolios encourage making connections between ideas. Revision of written work for portfolios improves learning by confronting misconceptions. As one student put it, "writing the portfolio definitely helps me learn the content, I don't usually look at test grade comments but the portfolio forces me to reread and ask questions about the questions I got wrong."

Based on this classroom research I plan to continue with the use of reflective writing as an embedded method of assessing students' conceptual understanding within coursework. Student revision of written work was beneficial to developing vocabulary utilization and making connections between concepts. However, I am considering changing the format of the submitted portfolio into an expository essay. For each lab report, students would be asked to write a single paragraph summary of results. This would require the identification of the primary claim and elucidating the supporting evidence and explanation of reasoning. Individual summary paragraphs would then be combined into a unit essay. The introduction and conclusion paragraphs would offer students opportunity to connect crosscutting concepts to the context of their own lives. In addition to reducing the monotony of writing and reading the same reports twice, students would be more engaged with skills of organizing more comprehensive writing samples. I would also like to incorporate more peer review where students could read each other's entries and provide feedback.

The process of designing, implementing, and reflecting on this classroom research has been beneficial to my growth as a teacher. The systematic study of classroom assessment techniques and their potential to affect instructional outcomes has changed the way I incorporate assessment into planning lessons. The application of liberal arts writing and learning strategies into my science classroom has deepened my appreciation of the value and utility of the writing process to develop and express thought. While I may not employ the degree of analytical detail associated with this research again soon, the value of systematic reflection on the outcomes of intentional pedagogical adjustments has proven to be a source of unexpected and valuable insight into how I teach and how my students learn.

REFERENCES CITED

Adu-Gyamfi, K., Bossé, M. J., & Faulconer, J. (2010). Assessing Understanding Through Reading and Writing in Mathematics. *International Journal for Mathematics Teaching and Learning*, *11*(5), 1-22.

Cervetti, G. & Pearson, P. (2012). Reading, writing, and thinking like a scientist. *Journal of Science Education and Technology 20 (3)*, 258-269.

Delbarton Program of Studies. (2018) Retrieved March 20, 2018 from https://www.delbarton.org/uploaded/documents/academics/DelCGuide2018-2019.pdf

Delbarton Mission Statement. (2018). Retrieved March 20, 2018 from https://www.delbarton.org/about/our-mission

Deresiewicz, W. (2014), *Excellent Sheep: the miseducation of the American elite and the way to a meaningful life.* New York: Free Press Publishers.

Diveny, P. & Aucoin, R. (2016). *Excellence by Design: Report of the Visiting Team for Accreditation of Delbarton School*. Middle States Association of Colleges and Schools, Philadelphia, Pennsylvania. Retrieved March 20, 2018, from http://www.delbarton.org/uploaded/documents/academics/Delbarton_Middle_States_Report.pdf

Gibbs, G., & Simpson, C. (2005). Conditions Under Which Assessment Supports Students' Learning. *Learning and teaching in higher education*, (1), 3-31.

Grymonpre, K., Cohn, A. & Solomon, S. (2012). Getting past "just because": Teaching writing in science class. *Science Scope*, *35 (5)*, 24-31.

Jordan, J. (2004). The Use of Writing as Both a Learning and an Assessment Tool. *Presentation at ARTIST Roundtable Conference. Lawrence University, Appleton, WI.* Retrieved January 26, 2018, from http://www.rossmanchance.com/artist/proceedings/jordan.pdf

Kamenetz, A. (2015). *The Test: why our schools are obsessed with standardized testing but you don't have to be.* New York: PublicAffairs Publishers.

Lemov, D., Driggs, C., & Woolway, E. (2016). *Reading Reconsidered: a practical guide to rigorous literacy instruction.* San Francisco: Jossey-Bass Publishers.

Mayer, J., & Hillman, S. (1996). Assessing Students' Thinking Through Writing. *The Mathematics Teacher*, *89*(5), 428.

McNeill, K. & Krajcil, J. (2009). Synergy between teacher practices and curricular scaffolds to support students in using domain-specific and domain-general knowledge in writing to explain phenomena. *Journal of the Learning Sciences, 18:3*, 416-460.

NGSS Lead States. (2013). *Next Generation Science Standards: For States, By States*. Washington, DC: National Academies Press.

Patterson, E. (2001). Structuring the Composition Process in Scientific Writing. *International Journal of Science Education*, 23, 1-16.

Reiser, B., Berland, L. & Kenyon, L. (2012). Engaging students in the scientific practices of explanation and argumentation; Understanding *A Framework for K-12 Science Education*. *Science Scope, 35 (8),* 6-11.

Tyre, P. (2008). *The Trouble with Boys: A surprising report card on our sons, their problems at school, and what parents and educators must do.* New York: Three Rivers Press.

APPENDICES

APPENDIX A

MONTANA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD RESEARCH EXEMPTION

INSTITUTIONAL REVIEW BOARD

For the Protection of Human Subjects
FWA 00000165

MONTANA STATE UNIVERSITY

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

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

MEMORANDUM

TO: Brian Theroux and John Graves

FROM: Mark Quinn *Mark Quinn CJ*
Chair, Institutional Review Board for the Protection of Human Subjects

DATE: May 1, 2018

RE: *"Use of Writing Portfolios in Place of Traditional Science Exams" [BT050118-EX]*

The above research, described in your submission of May 1, 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.

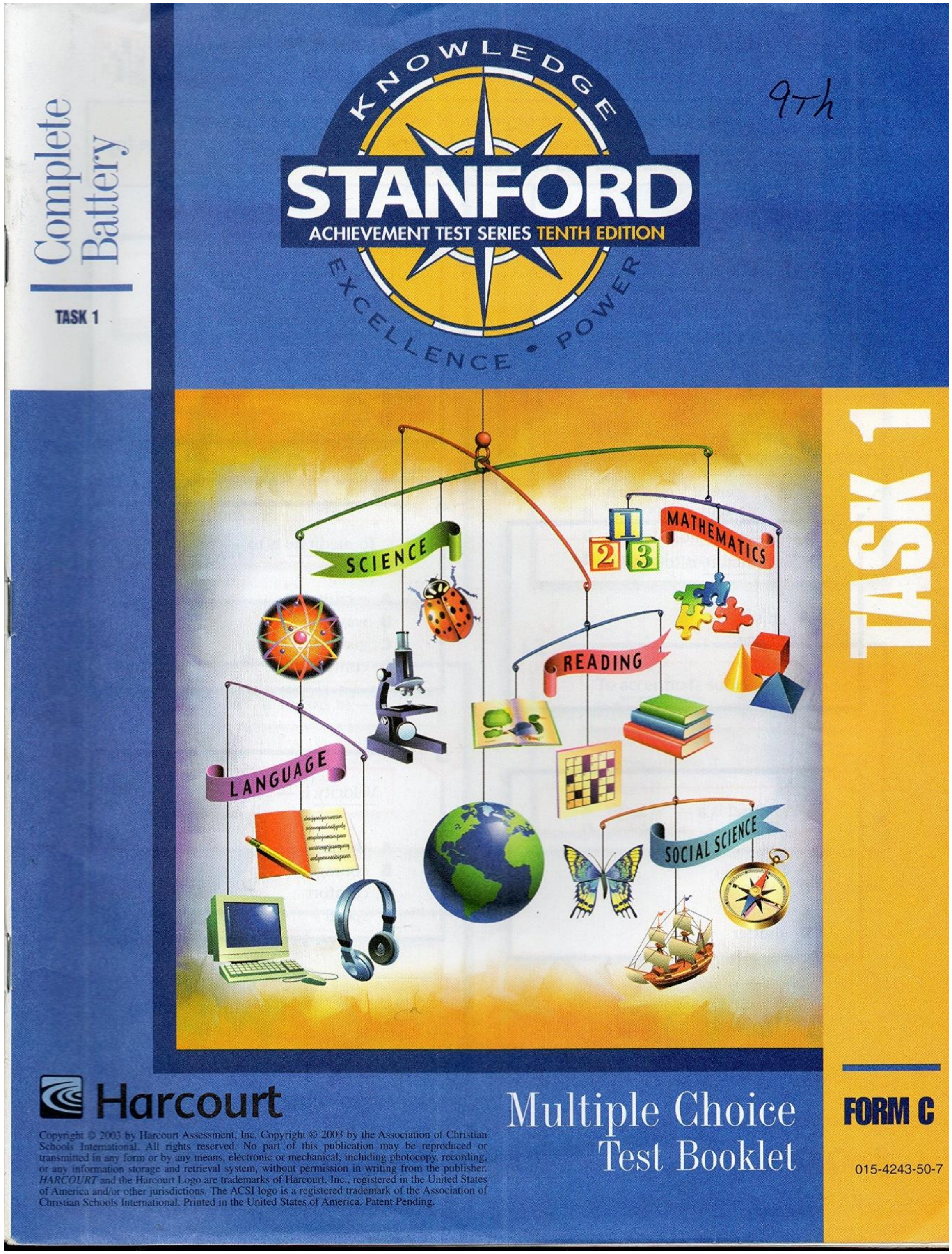
____ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (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

SAT SCIENCE SUBJECT TEST


Complete Battery
TASK 1
KNOWLEDGE
STANFORD
ACHIEVEMENT TEST SERIES TENTH EDITION
EXCELLENCE • POWER
9th
SCIENCE
MATHEMATICS
READING
LANGUAGE
SOCIAL SCIENCE
TASK 1
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Multiple Choice
Test Booklet
FORM C
015-4243-50-7

APPENDIX C

MULTIPLE CHOICE TESTS

Biological Principles Test Multiple Choice

Question 1 (1 point)
Biology is the study of
a plants and animals b the natural world c all living things d animals

Question 2 (1 point)
Homeostasis refers to the
a the status of Homo sapiens species b organization of cell structures
c chemical reactions transferring energy d maintaining stable conditions

Question 3 (1 point)
Photosynthesis is part of a plant's
a metabolism b response to stimuli c development d homeostasis

Question 4 (1 point)
The ability of a microscope to show details clearly is called
a resolution b HDMI c magnification d pixilation

Question 5 (1 point)
An image seen using a 15x ocular lens and a 25x objective lens has a magnification of
a 375x b 100x c 400x d 10x e 40x

Question 6 (1 point)
The smallest unit capable of all life functions is:
a organelle b tissue c organism d cell

Question 7 (1 point)
The metric system unit for temperature that we will use in this class is
a Fahrenheit b Kelvin c Celsius d Rankine

Question 8 (1 point)
The idea that life may have started with molecules of RNA is based on the observation that RNA can
a be more stable than DNA b conduct all the characteristic properties of life
c be a variety of shapes and act as an enzyme d link fats to form proteins

Question 9 (1 point)
The first cells were most likely:
a aerobic autotrophic eukaryotes b anaerobic heterotrophic prokaryotes
c anaerobic heterotrophic eukaryotes d aerobic heterotrophic prokaryotes

Question 10 (1 point)
Which scientist conclusively demonstrated that the principle of spontaneous generation was not correct?
a Francesco Redi b Lazzaro Spallanzani c Mike Russell d Louis Pasteur

Question 11 (1 point)
Which hypothesis proposed a specific method for the formation of photosynthetic eukaryotes from heterotrophic prokaryotes?
a chemosynthesis b endosymbiosis c spontaneous generation d biogenesis

Question 12 (1 point)
What self-replicating molecule had to exist in order for the first cells to form?
a RNA b oxygen c cell d ATP

Question 13 (1 point)
A French botanist wrote in 1609, "From a tree leaves are falling; upon one side they strike the water and slowly turn into fishes, upon the other they strike the land and turn into birds." What hypothesis was this botanist describing?
a evolution b endosymbiosis c spontaneous generation d biogenesis

Question 14 (1 point)
The science of naming and classifying organisms is called
a systematics b taxonomy c taxidermy d cladistics

Question 15 (1 point)
An organism's scienti_c name consists of its
a genus and family b species only c species and family d genus and species

Question 16 (1 point)
A bacteria that obtains its energy from light and carbon molecules from other organsims is called a
a chemoautotroph b chemoheterotroph c photoheterotroph d photoautotroph

Question 17 (1 point)
An organism, like *Mycobacterium tuberculosis*, that needs oxygen to live is categorized:
a obligate aerobe b obligate anaerobe
c facultative anaerobe d facultative aerobe

Question 18 (1 point)
Which group of prokaryotes may have established Earth's oxygen-rich atmosphere?
a proteobacteria b cyanobacteria c thermoacidophiles d methanogens

Question 19 (1 point)
Viruses are not alive because they
a do not grow b lack cell parts c do not metabolize d all of the above

Question 20 (1 point)
Which scientists are credited with providing the foundations of the theory of evolution?
a Watsin and Crick b Pasteur and Spallanzani
c Darwin and Wallace d Koch and Flemming

Biological Chemistry Test Multiple Choice

Question 1 (1 point)
The concentraton of hydronium ions in a solution with a pH of 4 is how many times that of a solution with a pH of 2?
a 100 b 10 c 2 d 20 e 200

Question 2 (1 point)
Sodium chloride (table salt) is an example of a compound containing
a hydrogen bonds b peptide bonds c covalent bonds d ionic bonds

Question 3 (1 point)
Charged particles that move around the outside of an atom are called
a electrons b ions c protons d neutrons

Question 4 (1 point)
Which of the following represents the correct order of states of matter from that having the slowest moving particles to that having the fastest
moving particles?
a solid, gas, liquid b liquid, solid, gas c liquid, gas, solid d solid, liquid, gas
e gas, liquid, solid f gas, solid liquid

Question 5 (1 point)
An attachement between atoms that results from the atoms sharing one or more pairs of electrons.
a covalent bondb ionic bond c hydrogen bond d peptide bond

Question 6 (1 point)
Monomers link to form polymers through a chemical reaction called
a a condensation reaction b a reduction reaction
c a hydrolysis reaction d an oxidation reaction

Question 7 (1 point)
A compound that is stored as glycogen in animals and as starch in plants is
a cellulose b glucose c fatty acid d adenosine diphosphate

Question 8 (1 point)
The three molecules shown below are:
a monomers b isomers c steroids d polymers

Question 9 (1 point)
Whithout enzymes, the chemical reactions in your body would
a happen too fast b create different products c occur too slowly d never stop

Question 10 (1 point)
ATP contains ___ phosphate groups

a 0 b 1 c 2 d 3 e 4

Question 11 (1 point)
Which atoms are involved in a peptide bond?

a carbon and oxygen b carbon and nitrogen
c phosphorus and nitrogen d phosphorus and carbon

Question 12 (1 point)
Redox reactions

a do not occur in living things b always involve oxygen
c involve the transfer of electrons between atoms
d involve either reduction or oxidation, but not both at the same time

Question 13 (1 point)
An acid is a solution with more

a hydroxide ions than sodium ions b hydroxide ions than hydronium ions
c sodium ions than hydroxide ions d hydronium ions than hydroxide ions

Question 14 (1 point)
Organic compounds contain

a carbon and other elements b only carbon and oxygen
c only carbon d elements other than carbon

Question 15 (1 point)
The number of bonds an individual carbon atom can form is

a 1 b 2 c 3 d 4

Question 16 (1 point)
A covalent bond formed when two atoms share a pair of electrons is called a

a single bond b triple bond c double bond d dual bond

Question 17 (1 point)
The mot important function of nucleic acids is

a storing energy b storing information related to heredity
c catalyzing chemical reactions
d forming a barrier between the inside and outside of a cell

Question 18 (1 point)
Biology is the study of

a energy b life c mater d nature

Question 19 (1 point)
The state of matter in which particles move most rapidly is

a gas b liquid c solid

Question 20 (1 point)
Every chemical reaction involves

a a change in the state of matter b a transfer of energy c acids and bases d organic molecules

Cell Structure, Function, and Reproduction Test Multiple Choice

Question 1 (1 point)
System of protein signals in the cell that start or stop the next phase of the cell cycle from occurring
a sex chromosome b checkpoint c synapsis d centrosomes

Question 2 (1 point)
Cells containing two copies of each autosome are called
a histone b diploid c haploid d gametes

Question 3 (1 point)
One difference between a eukaryotic and prokaryotic cell is that only
a prokaryotic cells are surrounded by a cell membrane
b prokaryotic cells have a nucleus
c eukaryotic cells have genetic information
d eukaryotic cells have membrane bound organelles

Question 4 (1 point)
Cancer is the loss of control of
a cytokinesis b DNA synthesis c the cell cycle d meiosis e mitosis

Question 5 (1 point)
Copies of chromosomes containing genes for the same traits
a homologous chromosomes b autosomes
c sex chromosome d chromatin

Question 6 (1 point)
Prokaryotic cells reproduce by a process called
a binary fission b mitosis c meiosis d binary fusion

Question 7 (1 point)
During interphase the DNA in a eukaryotic cell is in a form called
a centrosome b chromosome c chromatin d chromatid

Question 8 (1 point)
Durring prophase tightly packed copies of DNA in eukaryotic cell are held together by
a centrosomes b diploids c haploids d centromeres

Question 9 (1 point)
The production of egg cells
a mitosis b oogenesis c spermatogenesis d meiosis

Question 10 (1 point)
Division of the nucleus resulting in new cells with half the number of chromosomes of the original cell

a mitosis b binary fission c meiosis d synapsis

Question 11 (1 point)
The correct order of the phases of the cell cycle is
a anaphase, cytokinesis, interphase, metaphase, prophase, telophase
b interphase, prophase, metaphase, anaphase, telophase, cytokinesis
c interphase, cytokinesis, prophase, metaphase, anaphase, telophase
d prophase, anaphase, metaphase, telophase, interphase, cytokinesis

Question 12 (1 point)
Spindle fibers that attach centromeres to centrosomes are called
a kinetochore fibers b polar fibers c synaptic fibersd meiotic fibers

Question 13 (1 point)
Humans have 46 chromosomes in all cells except sperm and egg cells. How many of these chromosomes are autosomes?
a 2 b 46 c 44 d 23

Question 14 (1 point)
Cells are limited in size by the
a speed materials are able to move in and out through the cell membrane
b number of chromosomes they possess
c volume of material the cell can hold within itself
d rate the cell uses its DNA

Question 15 (1 point)
This is when portions of tetrads twist around each other, break off and reattach to adjacent chromatids
a down syndrome b cancer c crossing over d independent assortment

Question 16 (1 point)
Cells that have a high energy requirement would be expected to have many
a lysosomes b chromosomesc flagella d mitochondria

Question 17 (1 point)
A cell that contains a cell wall, chloroplasts, and a central vacuole is a
a plant cell b fungi cell c animal cell d bacteria cell

Question 18 (1 point)
Organelles that are surrounded by two membranes and contain DNA are the
a nucleus, chloroplast, and central vacuole
b endoplasmic reticulum, golgi, and central vacuole
c nucleus, chloroplast, and mitochondria
d nucleus, endoplasmic reticulum, and golgi

Question 19 (1 point)
A pair of homologous chromosomes aligned next to each other
a tetradb oogenesis c synapsis d metaphase

Question 20 (1 point)
Substances produced by the cell and exported outside of the cel would pass through the
a endoplasmic reticulum and golgi b vacuoles and centrosomes
c mitochondria and golgi d nucleus and mitochondria

Cellular Homeostasis, Transport and Immunity Test Multiple Choice

Question 1 (1 point)
The process by which water molecules move across a cell membrane from an area of higher concentration to an area of lower concentration is called
a diffusion b turgor pressure c osmosis d equilibrium

Question 2 (1 point)
A diagnosis of AIDS is made when a person has
a few T cells b a positive antigen test c an HIV infection d few B cells

Question 3 (1 point)
The maintenance of a stable level of internal conditions even though environmental conditions are constantly changing.
a isotonic b diffusion c osmosis d homeostasis

Question 4 (1 point)
Vaccines are effective in preventing disease because they
a contain B cells and T cells b trigger immune response without causing disease
c contain antibodies directed against specific pathogens d contain pathogens

Question 5 (1 point)
The process that involves the active transport of fluids using vesicles is _.
a phagocytosis b osmosis c diffusion d pinocytosis

Question 6 (1 point)
The introduction of antigens into the body to cause immunity is
a vaccination b allergy c opportunistic infection d autoimmune

Question 7 (1 point)
Interleukins are secreted by
a helper T-cells b neutrophils c cytotoxic T-cells d plasma cells

Question 8 (1 point)
The movement of solute molecules from an area of higher concentration to an area of lower concentration is called
a hypertonic b hypotonic c osmosis d diffusion

Question 9 (1 point)
Robert Koch developed a system for
a producing vaccines b treating allergic reactions
c reducing the spread of pathogens d identifying specific pathogens

Question 10 (1 point)
In the immune system, macrophages
a display antigens b kill infected body cells
c produce antibodies d stimulate the inflammatory response

Question 11 (1 point)
Organelles that collect excess water and pump it out of the cell
a osmosis b carrier proteins c contractile vacuoles d phagocytosis

Question 12 (1 point)
Facilitated-diffusion carrier proteins and cell membrane pumps both
a are specific for the kinds of substances they transport
b transport substances up their concentration gradients
c require an input of energy
d carry our active transport

Question 13 (1 point)
Any agent that causes an infectious disease is called a
a interferon b pathogen c virus d antigen

Question 14 (1 point)
Molecules that cannot easily di□use through the cell membrane due to size or solubility enter the cell through _ in a process called _.
a vesicles, facilitated diffusion b carrier proteins, active transport
c Na-K pumps, active transport d carrier proteins, facilitated diffusion

Question 15 (1 point)
The process that involves the active transport of large particles or whole cells using vesicles is _.
a facilitated diffusion b phagocytosis c contractile vacuoles d pinocytosis

Question 16 (1 point)
Julius Petri developed a procedure for
a identifying specific pathogens b producing vaccines
c reducing the spread of pathogens d growing pathogens outside of a host

Question 17 (1 point)
An immune response to an antigen that produced little or no response in general population
a Allergy b AIDS c Opportunistic infection d Autoimmune disease

Question 18 (1 point)
When a human red blood cell is placed in a hypotonic environment, it will
a undergo plasmolysis b be at equilibrium
c undergo cytolysis d lose turgor pressure

Question 19 (1 point)
Cells that make antibodies
a Macrophages b B cells c Neutrophils d T cells

Question 20 (1 point)
Some substances can cross the cell membrane without any input of energy from the cell in a process known as

a cytolysis b pinocytosis c passive transport d active transport

Microorganisms Test Multiple Choice

Question 1 (1 point)
Which of the following is not effective in preventing or treating a viral disease?
a antibiotics b vaccines c washing hands d vector control

Question 2 (1 point)
Viral genetic information that has been inserted into a host cell chromosome is called
a inactivated virus b attenuated virus c provirus d protease

Question 3 (1 point)
Viral DNA can become integrated into the host cell's DNA during
a neither the lytic or lysogenic cycle b the lytic cycle
c both the lytic and lysogenic cycles d the lysogenic cycle

Question 4 (1 point)
Gram negative bacteria
a retain the sudan red stain, not the crystal violet stain b are all pathogenic
c retain the crystal violet stain, not he sudan red stain d are killed by penicillin

Question 5 (1 point)
Archaea and Bacteria are placed in separate domains because
a their DNA sequences are very different
b archaea have cell walls made of peptidoglycan
c bacteria lack cell membranes
d proteins of bacteria have no amino acids

Question 6 (1 point)
Which of the following statements is true?
a antibiotics have no negative side effects
b hospitals are completely sterile environments where no bacteria can survive
c antibiotic resistance can develop when people do not use antibiotics correctly
d the number of antibiotic resistant bacteria infections is decreasing every year

Question 7 (1 point)
Bacterial diseases of the intestines are usually transmitted by
a sneezes and coughs b blood transfusions
c shaking hands d contaminated water or food

Question 8 (1 point)
Which of the following is NOT a structure that provides the type of movement indicated?
a spiral shape - corkscrew motion b flagellum - moving forward or side to side
c slime layer - allowing for gliding motion d pilus - crawling motion

Question 9 (1 point)
Reverse transcriptase
a makes a protein copy of RNA b makes an RNA copy of a protein
c makes a DNA copy of RNA d makes an RNA copy of DNA

Question 10 (1 point)
Photoautotrophic bacteria obtain energy from
a feeding on living cells b the sun c salt d harnessing chemicals

Question 11 (1 point)
Which of the following is NOT a viral disease?
a rabies b hepatitis c influenza d tetanus

Question 12 (1 point)
In what decade were viruses discovered?
a 1970's b 1910's c 1950'5 d 1930's

Question 13 (1 point)
Bacteria cells lack
a nucleus b flagella c the ability to reproduce d chromosomes

Question 14 (1 point)
Groups of staphylococci look like
a chain of rods b chain of balls c cluster of balls d cluster of rods

Question 15 (1 point)
The only characteristic of life that viruses possess is
a cellular organization b metabolism c reproduction d heredity

Question 16 (1 point)
A bacterial disease that is transmitted by a tick vector is
a tuberculosis b lyme disease c cholera d gonorrhea

Question 17 (1 point)
Which of the following is an example of a temperate virus
a Thermoacidophile b Common Cold c Flu d HIV

Question 18 (1 point)
Which of the following incorrectly describes an archea and its characteristics?
a thermoacidophile - hot acidic environment b halophile - high salt environment
c methanogen - aerobic environment d cyanobacteria – photosynthetic

Question 19 (1 point)
Biologists know that viruses
a are the smallest organisms b contain genetic information in a protein coat
c contain protein surrounded by a nucleic acid coat d all the same shape

Question 20 (1 point)
Viruses can enter new host cells by
a endocytosis b osmosis c diffusion d exocytosis

APPENDIX D

SHORT ANSWER TESTS

Biological Principles Test Short Answer

Answer the following questions using complete sentences and proper terminology.

1. Distinguish between:
   a. Organ vs Organelle: using yourself as an example (2pts)
   b. Resolution vs Magnification: using a microscope as an example (2pts)

2. Some scientists want to study the connection between opioid pain-killers and constipation. They set up an experiment in which people are given a pill containing opioid pain-killers.
   a. What are the dependent and independent variables in their experiment? (2pts)
   b. What should the control group consist of? (1pt)
   c. Write a possible hypothesis for this experiment. (1pt)

3. Summarize the most significant procedural steps you would take to obtain a focused image of a specimen on a compound light microscope. Use the proper names of microscope parts for each step. (3pts)

4. How would an endosymbiotic relationship be mutually beneficial for two prokaryotic heterotrophs? (2pts)

5. Identify and describe 2 traits heterotrophic anaerobic prokaryotes share with autotrophic aerobic eukaryotes? (2pts)

6. Describe how Pasture’s experiment differed from Spallanzani’s, and how his results led to the improvement of human society. (3pts)

7. Identify the base units of Distance and Mass in the metric system, and explain why doing conversions with these units is easier than with the traditional English units. (2pts)

Biological Chemistry Test Short Answer

Answer the following questions using complete sentences and proper terminology.

1. Write the molecular formula and structural formula, for water. Add (-) and (+) symbols to indicate polarity on the structural formula. (3pts)

2. Using proper symbols, write the chemical equations for the following statements:
   a. "the reaction of two protons with two electrons and one oxygen molecule produces two water molecules" (2pts)
   b. "the hydrolysis reaction breaking apart sucrose produces a glucose and a fructose" (2pts)

3. Describe the action and effect of an enzyme on a chemical reaction. (2pts)

4. Breaking down ATP provides energy to drive other metabolic reactions. Draw and label an energy diagram for the hydrolysis of ATP. Identify the products and reactants. (2pts)

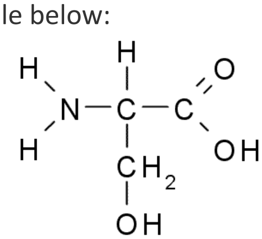
5. Explain the relationship between amino acids and protein structure. (2pts)

6. Compare and contrast unsaturated and saturated fats? Which do you want to eat less of and why? (2pts)

7. List three properties of water and state their importance to biology. (3pts)

8. Summarize how large polysaccharides, such as cellulose, are synthesized and broken down. (2pts)

9. Consider the organic molecule below:



   a. Circle and label the functional groups in the molecule. (2pts)
   b. What makes this an organic molecule? (1pt)
   c. Identify the type of organic molecule represented. (1pt)

Cell Structure, Function, and Reproduction Test Short Answer

Answer the following questions using complete sentences and proper terminology.

1. A great deal of research on the causes and possible cures for cancer focuses on mitosis. Why? (2pts)

2. Describe the three basic parts of a cell. (3pts)

3. Compare and contrast:
    a) prophase and prophase 1 (2pts)
    b) anaphase and anaphase 1 (2pts)

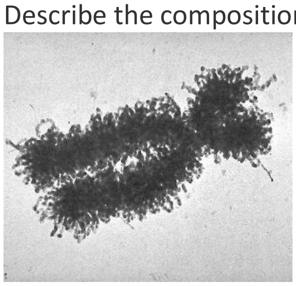
4. Describe the structure and function of a cell membrane. (3pts)

5. Identify and describe the structure and function of two organelles other than the nucleus. (4pts)

6. Explain how prokaryotes, plant cells and animal cells could be distinguished from each other under a light microscope. (3pts)

7. How do the end products of meiosis differ from the end products of mitosis? (2pts)

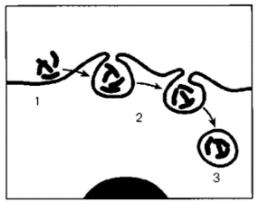
8. Describe the composition of the structure shown below. (2pts)

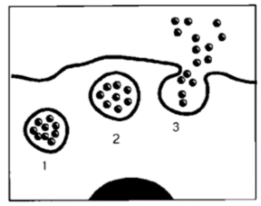


Cellular Homeostasis, Transport, and Immunity Test Short Answer

Answer the following questions using complete sentences and proper terminology.

1. The illustration below shows the active transport done by macrophages. Identify the substances and methods of transport, and explain the significance of the processes taking place in Figure "A" and Figure "B." (4pts)





2. Describe two ways sodium ions are transported across the cell membrane of a nerve axon. (2pts)

3. Data were obtained from an experiment in which paramecia were placed in different salt concentrations and the rate at which the contractile vacuole contracted to pump out excess water was recorded.

Salt concentration	Rate of contractile vacuole contractions / minute
Very high	2
High	8
Medium	15
Low	22
Very low	30

   a. Explain the observed relationship between salt concentration and rate of contractile vacuole contraction? (2pts)
   b. If something caused a paramecium's contractile vacuole to stop contracting, what would you expect to happen? Why? (1pt)
   c. Explain how plant cells respond to hypertonic and hypotonic environments. (2pts)

4. Compare and contrast the actions of the following in the immune response:
   a) natural killer cells and cytotoxic T cells (2pts)
   b) interleukins and antibodies (2pts)

5. Summarize Koch's postulates for identifying a disease causing agent. (3pts)

6. What does an infected cell release to instigate the inflammatory response, and what are its effects? (2pts)

7. Distinguish between allergy and autoimmune disease and acquired immunodeficiency syndrome. (3pts)

8. Using dialysis tubing as an example, explain how a semi-permeable membrane can control diffusion of solutes. (2pts)

Microorganisms Test Short Answer

Answer the following questions using complete sentences and proper terminology.

1. Compare the effectiveness of two different ways to prevent the spread of pathogenic diseases. (2pts)

2. Compare and contrast the Lysogenic and Lytic cycles of viral infection. (2pts)

3. Describe the connection between some viruses and cancer in humans. (2pts)

4. Describe the common methods used to identify bacteria. (3pts)

5. Explain the symbiotic relationship between Rhizobium and leguminous plants, and the importance of this relationship to ecosystems. (3pts)

6. Explain how a bacterial population can develope resistance to an antibiotic. (2pts)

7. Describe three diferent wide-spread and large scale uses of bacteria. (3pts)

8. Summarize the discovery of viruses. (3pts)

APPENDIX E

WRITING PORTFOLIO ASSESSMENTS

BIOLOGICAL PRINCIPLES WRITING PORTFOLIO

First (5pts)
Combine all five writing samples from the unit into one document titled “LastName’s Biological Principles Portfolio.”

- The order of the writing samples should be:
  - Chapter One Summary
  - Oreo Lab
  - Microscope Lab
  - Chapter 14 Summary
  - Biogenesis Lab
- Each writing sample should have a title, written in all capital letters 14pt Arial font and centered at the top of the page.

Then (10pts)
Reread your written work from the unit and make suggested and desired edits.

- Use the “Line Editing Guide for Biology” to help identify desirable edits.
- Make all edits suggested by my comments and corrections.
  - If I commented on something once, my assumption is that you will make all corrections of a similar nature throughout the portfolio.
    - For example: use of proper punctuation, cropping and resizing images
- Rephrase question prompts into transitional phrases or sentences
- Add text as needed to connect ideas and enable an easy flow of reading.

Last (5pts)
Write a cover letter, addressed to your parent/guardian(s), introducing the portfolio and indicating how each of the writing samples is connected to the theme: Biological Principles.

BIOLOGICAL CHEMISTRY WRITING PORTFOLIO

First (5pts)
Combine all four writing samples from the unit into one document titled "LastName's Biological Chemistry Portfolio."

- The order of the writing samples should be:
  - Chemistry of Life Demonstration Summary
  - Lactaid Lab
  - Candy Crush Word Splash
  - Protein Folding Lab
- Each writing sample should have a title, written in all capital letters 14pt Arial font and centered at the top of the page.

Then (10pts)
Reread your written work from the unit and make suggested and desired edits.

- Use the "Line Editing Guide for Biology" to help identify desirable edits.
- Make all edits suggested by my comments and corrections.
  - If I commented on something once, my assumption is that you will make all corrections of a similar nature throughout the portfolio.
    - For example: use of proper punctuation, cropping and resizing images
- Rephrase question prompts into transitional phrases or sentences
- Add text as needed to connect ideas and enable an easy flow of reading.

Last (5pts)
Write a cover letter, addressed to your parent/guardian(s), summarizing the unit, introducing the portfolio and indicating how each of the writing samples is connected to the theme: Biological Chemistry.

CELL STRUCTURE, FUNCTION, AND REPRODUCTION WRITING PORTFOLIO

First (5pts)
Combine all four writing samples from the unit into one document titled "LastName's Cell Structure Portfolio."

- The order of the writing samples should be:
  - Gummy Bear Lab
  - Cell Staining Lab
  - Chromosome Word Splash
  - Mitosis Lab
  - Cells and Cancer Report
- Each writing sample should have a title, written in all capital letters 14pt Arial font and centered at the top of the page.

Then (10pts)
Reread your written work from the unit and make suggested and desired edits.

- Use the "Line Editing Guide for Biology" to help identify desirable edits.
- Make all edits suggested by my comments and corrections.
  - If I commented on something once, my assumption is that you will make all corrections of a similar nature throughout the portfolio.
    - For example: use of proper punctuation, cropping and resizing images
- Rephrase question prompts into transitional phrases or sentences
- Add text as needed to connect ideas and enable an easy flow of reading.

Last (5pts)
Write a cover letter, addressed to your parent/guardian(s), summarizing the unit, introducing the portfolio and indicating how each of the writing samples is connected to the theme: Cell Structure, Function, and Reproduction.

CELLULAR HOMEOSTASIS, TRANSPORT, AND IMMUNITY WRITING PORTFOLIO

First (5pts)
Combine all four writing samples from the unit into one document titled "LastName's Cell Homeostasis Portfolio."

- The order of the writing samples should be:
    - Dialysis Lab
    - Osteocytes and Neurons Word Splash
    - Protein Assay Lab
    - ELISA Lab
- Each writing sample should have a title, written in all capital letters 14pt Arial font and centered at the top of the page.

Then (10pts)
Reread your written work from the unit and make suggested and desired edits.

- Use the "Line Editing Guide for Biology" to help identify desirable edits.
- Make all edits suggested by my comments and corrections.
    - If I commented on something once, my assumption is that you will make all corrections of a similar nature throughout the portfolio.
        - For example: use of proper punctuation, cropping and resizing images
- Rephrase question prompts into transitional phrases or sentences
- Add text as needed to connect ideas and enable an easy flow of reading.

Last (5pts)
Write a cover letter, addressed to your parent/guardian(s), summarizing the unit, introducing the portfolio and indicating how each of the writing samples is connected to the theme: Cellular Homeostasis, Transport, and Immunity.

MICROORGANISMS WRITNG PORTFOLIO

First (5pts)
Combine all four writing samples from the unit into one document titled “LastName’s Microorganisms Portfolio.”

- The order of the writing samples should be:
  - Bacterial Identification Word Splash
  - Culturing Bacteria Lab
  - Antibiotic Resistance Lab
  - pGLO Transformation Lab
- Each writing sample should have a title, written in all capital letters 14pt Arial font and centered at the top of the page.

Then (10pts)
Reread your written work from the unit and make suggested and desired edits.

- Use the “Line Editing Guide for Biology” to help identify desirable edits.
- Make all edits suggested by my comments and corrections.
  - If I commented on something once, my assumption is that you will make all corrections of a similar nature throughout the portfolio.
    - For example: use of proper punctuation, cropping and resizing images
- Rephrase question prompts into transitional phrases or sentences
- Add text as needed to connect ideas and enable an easy flow of reading.

Last (5pts)
Write a cover letter, addressed to your parent/guardian(s), summarizing the unit, introducing the portfolio and indicating how each of the writing samples is connected to the theme: Microorganisms.

APPENDIX F

COURSE ENGAGEMENT QUESTIONNAIRE

Please note that participation in this survey is voluntary and participation or non-particiation will not effect a students grades or class standing in any way.

STUDENT ENGAGEMENT QUESTIONNAIRE

To what extent do the following behaviors, thoughts, and feelings describe *you, in this course.* Please rate each of them on the following scale:

5 = very characteristic of me
4 = characteristic of me
3 = moderately characteristic of me
2 = not really characteristic of me
1 = not at all characteristic of me

1. _____ Raising my hand in class
2. _____ Participating actively in small group discussions
3. _____ Asking questions when I don't understand the instructor
4. _____ Doing all the homework problems
5. _____ Coming to class every day
6. _____ Going to the professor's office hours to review assignments or tests, or to ask questions
7. _____ Thinking about the course between class meetings
8. _____ Finding ways to make the course interesting to me
9. _____ Taking good notes in class
10. _____ Looking over class notes between classes to make sure I understand the material
11. _____ Really desiring to learn the material
12. _____ Being confident that I can learn and do well in the class
13. _____ Putting forth effort
14. _____ Being organized

15. _____ Getting a good grade

16. _____ Doing well on the tests

17. _____ Staying up on the readings

18. _____ Having fun in class

19. _____ Helping fellow students

20. _____ Making sure to study on a regular basis

21. _____ Finding ways to make the course material relevant to my life

22. _____ Applying course material to my life

23. _____ Listening carefully in class

[Source: Handelsman, M. M., Briggs, W. L., Sullivan, N., & Towler, A. (2005). A measure of college student course engagement. *Journal of Educational Research, 98,* 184-191.]

APPENDIX G

SUPPLEMENTAL STATISTICAL ANALYSIS

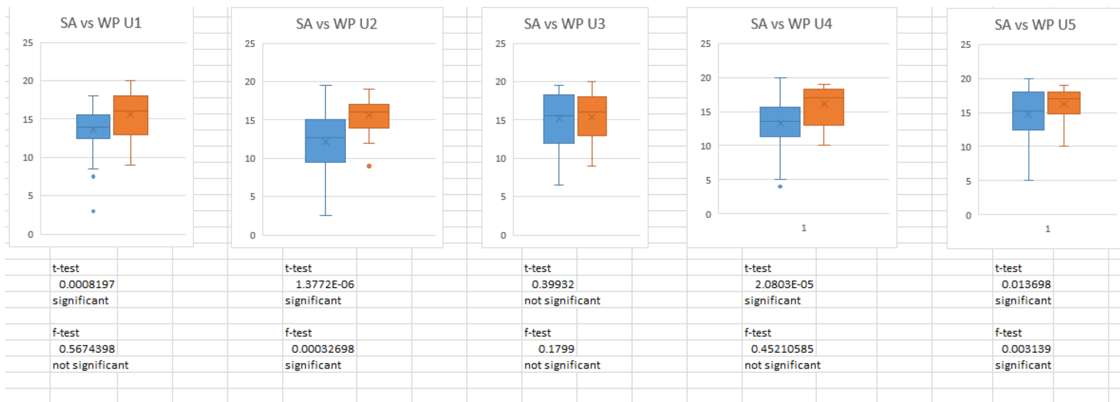


Figure 7. Comparison of short-answer (blue) and writing portfolio (orange) scores for students across five units of study (*N*=88). Results of t-test for averages and f-test of standard deviation indicated for each unit of study.

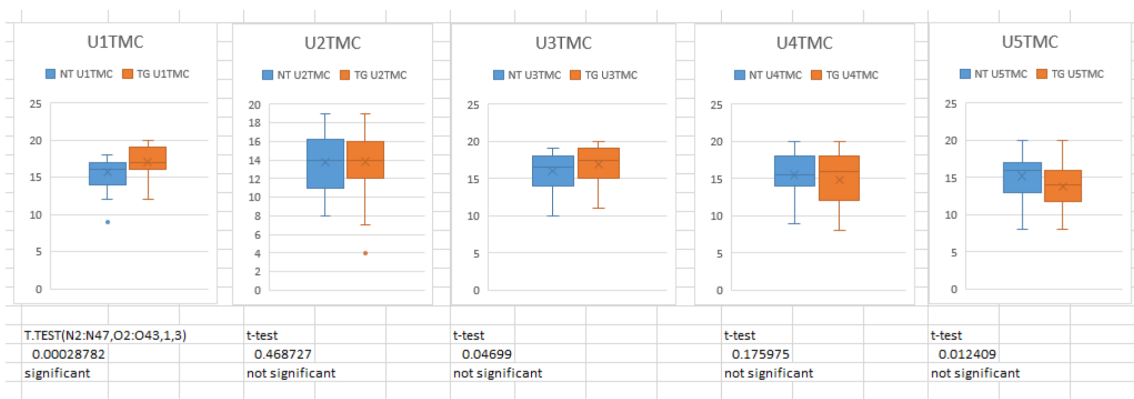


Figure 8. Comparison of multiple choice test scores between non-treatment (blue) and treatment (orange) groups across five units of study (*N*=88). Results of t-test for averages indicated for each unit of study.

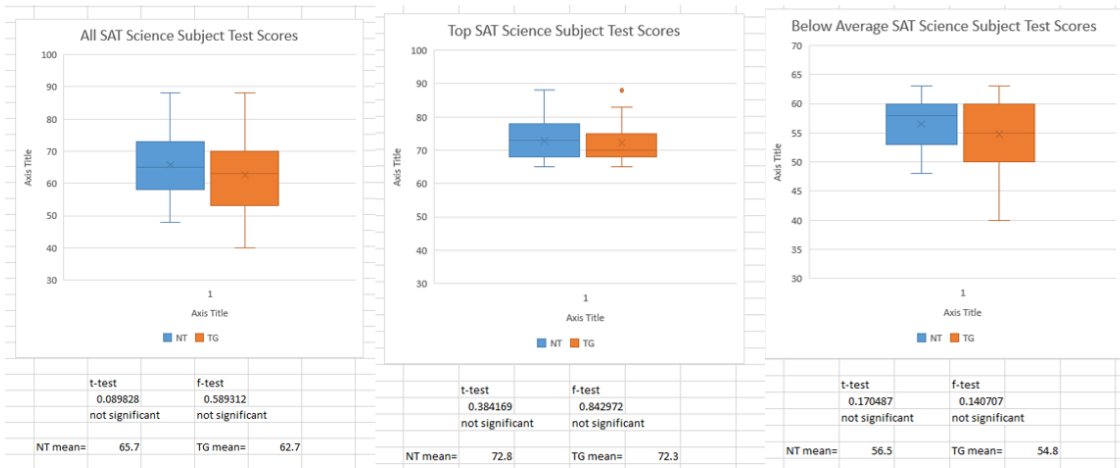


Figure 9. SAT science subject scores for non-treatment (blue) and treatment (orange) groups (*N*=88). (a) all students, (b) above average students, (c) below average students. T-test of means and f-test of standard deviation results noted.

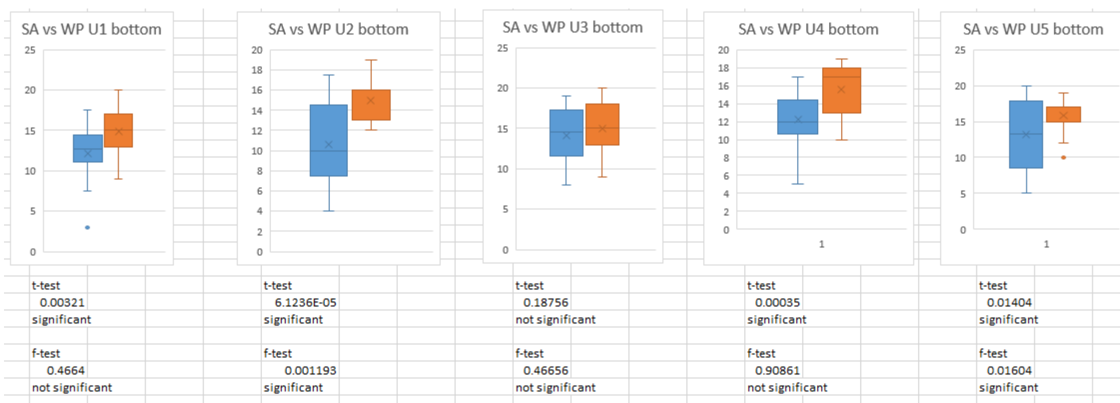


Figure 10. Comparison of conceptual understanding test scores for short-answer (blue) and writing portfolio (orange) groups of below-average SAT students (*N*=42). T-test of means and f-test of standard deviation results noted.

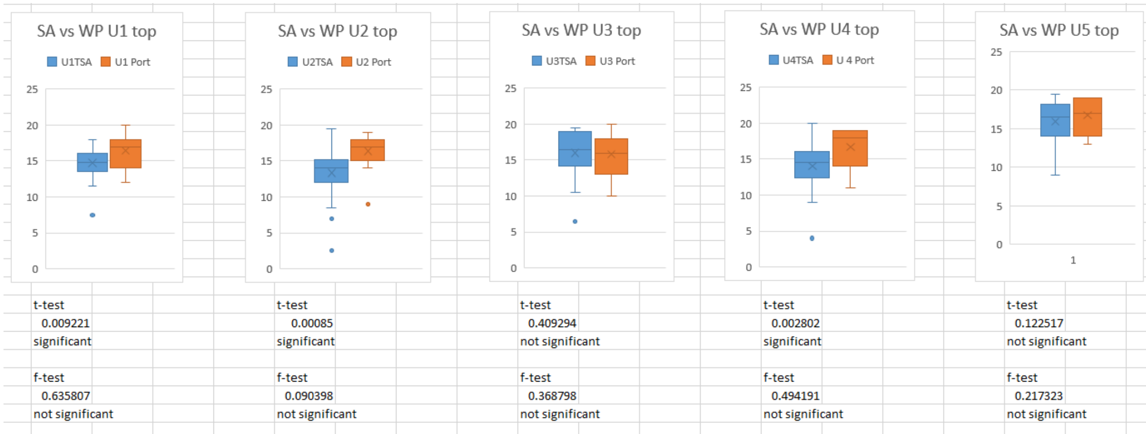


Figure 11. Comparison of conceptual understanding test scores for short-answer (blue) and writing portfolio (orange) groups of above-average SAT students (*N*=40). T-test of means and f-test of standard deviation results noted.

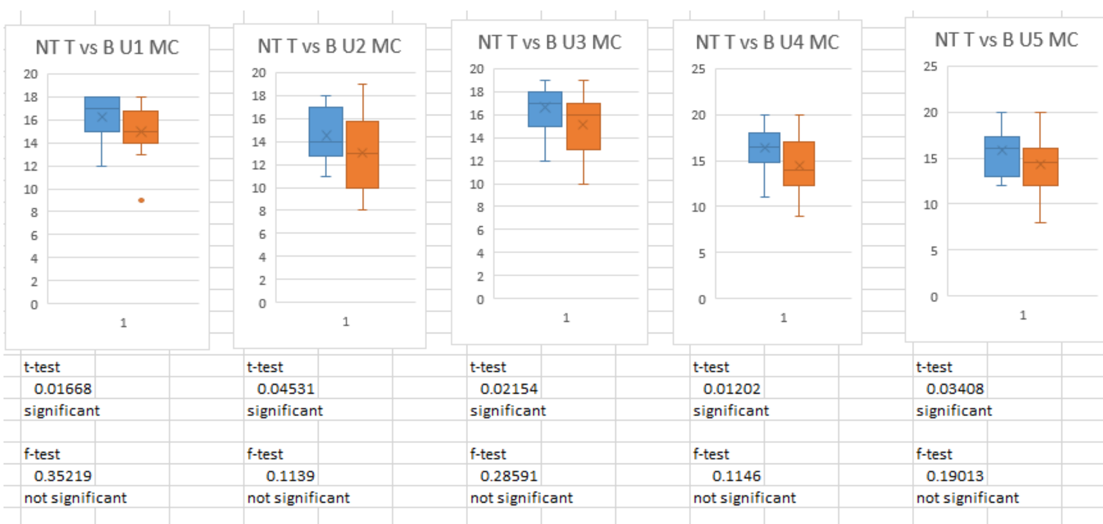


Figure 12. Comparison of multiple choice test scores between non-treatment students with above-average SAT scores (blue) and below-average SAT scores (orange) across five units of study. Results of t-test for averages indicated for each unit of study.

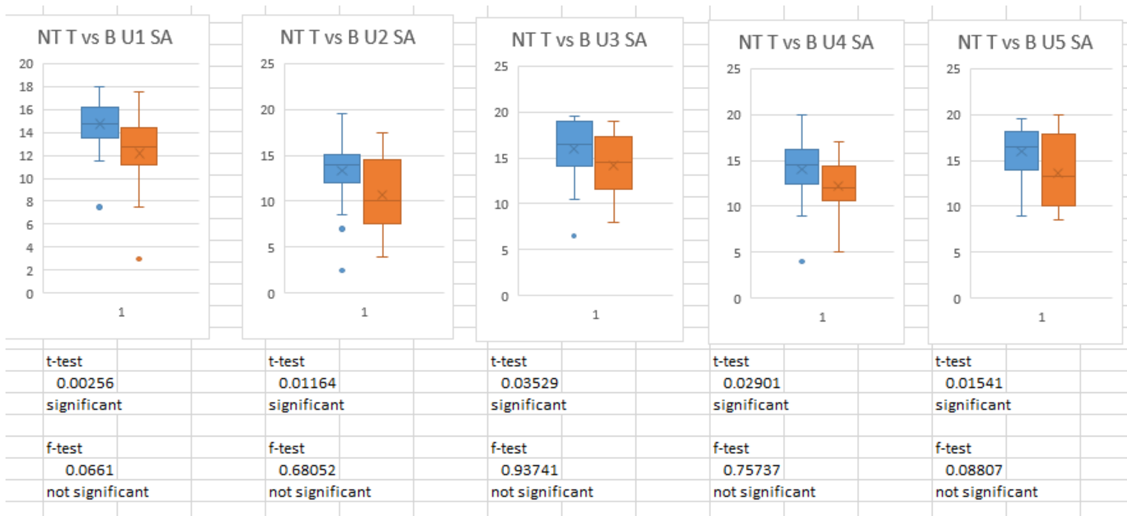


Figure 13. Comparison of short answer test scores between non-treatment students with above-average SAT scores (blue) and below-average SAT scores (orange) across five units of study. Results of t-test for averages indicated for each unit of study.

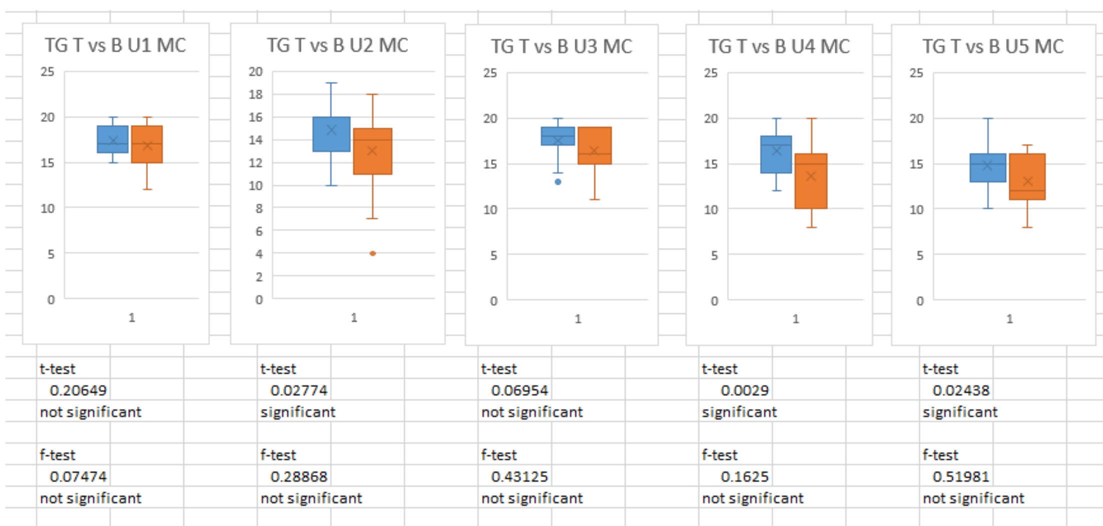
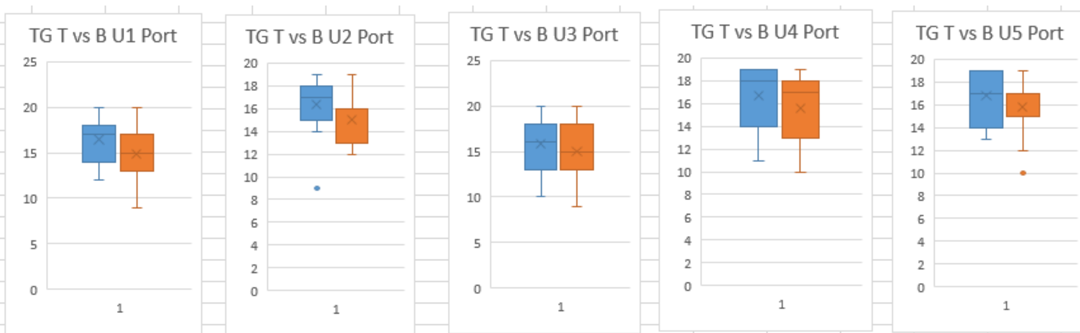


Figure 14. Comparison of multiple choice test scores between treatment group students with above-average SAT scores (blue) and below-average SAT scores (orange) across five units of study. Results of t-test for averages indicated for each unit of study.



t-test	t-test	t-test	t-test	t-test
0.0267	0.02722	0.18577	0.11561	0.09552
significant	significant	not significant	not significant	not significant
f-test	f-test	f-test	f-test	f-test
0.56799	0.23678	0.80648	0.79388	0.312
not significant	not significant	not significant	not significant	not significant

Figure 15. Comparison of portfolio test scores between students with above-average SAT scores (blue) and below-average SAT scores (orange) across five units of study. Results of t-test for averages indicated for each unit of study.

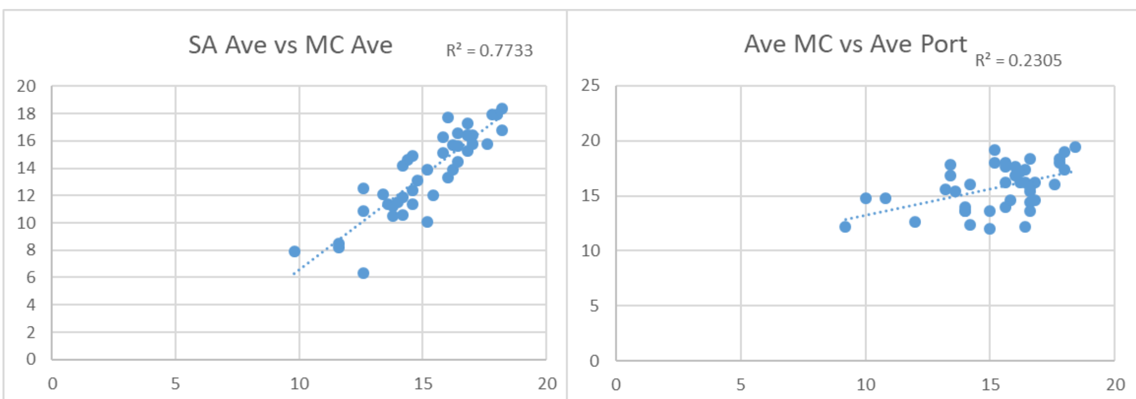


Figure 16. Correlation of average multiple choice test scores to average short answer score (left) and average portfolio score (right).

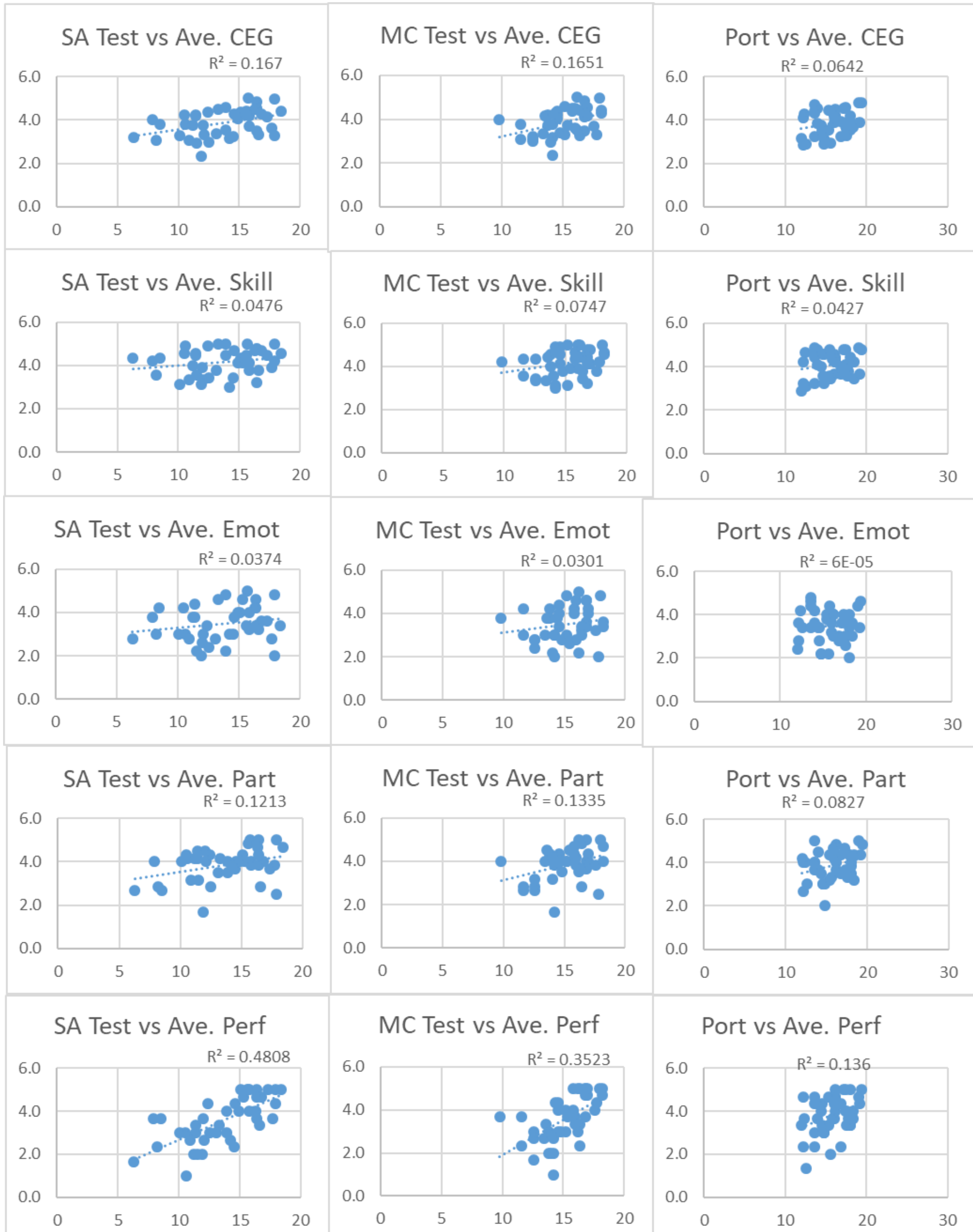


Figure 17. Correlation of CEQ Factors and short answer (left), multiple choice (middle), and portfolio (right) scores.