MISCONCEPTION PROBES IN HUMAN ANATOMY AND PHYSIOLOGY

by

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

of

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I would like to acknowledge the help and patience of all the MSSE staff for helping me to complete this capstone project. This capstone project has been heavily modified from what I had initially planned it to be. It has undergone a change in subject matter, two postponements, and finally a change from two classroom sections down to one on the first day of the semester. This has resulted in a great deal of frustration for me, and a lot of extra work in a relatively short amount of time. Initially all of this made me feel very dissatisfied and even disappointed with my capstone as I worked on it. John’s patience and support has helped me to realize that even a project that did not turn out as I intended can still have value. There are lessons to learn and further questions to be stimulated.

In particular, I would like to thank Dr. John Graves, Dr. Candace Goodman, Diana Paterson, and my good wife. The patience and support you have all given to me has made all the difference. Even more significant to me, is the example you have shown of how a positive and supportive relationship between a teacher and a student should be. I hope to repay your kindness and patience with my own students throughout my career.

Thank you.
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ABSTRACT

Learning is a process of acquiring knowledge and understanding. When students enter the classroom, they bring their current knowledge and understanding with them. Teachers build upon this knowledge to move students toward new levels of comprehension. The problem is that in many cases, students bring incorrect information or misconceptions into the classroom. When teachers add more upon these concepts, the students often end up with a blending of the correct and inaccurate information. Misconception probes are a tool that requires students to address these problematic concepts and allow teachers to identify the specific misconceptions that students have so that they can be corrected. This study investigated how the use of misconception probes would affect students in a science classroom. Specifically, the areas investigated were the impacts on learning and achievement and the impact on student confidence. Students were given misconception probes that focused on problem concepts within the selected unit, and then remedial instruction was given to address the misconceptions. Performance on the unit exams did not show a significant change; however, some students showed a marked decrease. Student metacognitive awareness of what they did and did not know increased. This resulted in students providing more accurate assessments of their confidence on the surveys given before the exams. This action research showed that misconception probes can be a valuable tool to help inform the teacher and to help students to recognize where their understanding is lacking.
INTRODUCTION AND BACKGROUND

The Cardston High School is a public high school in the southwestern part of Alberta, Canada. The school has students from the town of Cardston and the surrounding rural area including several smaller villages and hamlets, as well as approximately 150 students from the Blood Indian Reservation. The total student population is approximately 500 students in grades 9 through 12.

The elementary and junior high schools that feed into the high school are smaller schools that often have generalist teachers instead of science specialists, and limited budgets for science equipment. This results in students arriving at the high school with widely varying levels of knowledge, skills, and experiences in the sciences when compared to their peers. The students’ understanding of science can also be influenced by family, friends, social media, and television. These influences can lead to errors or misconceptions in their understanding about important scientific concepts. Students may struggle to learn new or more advanced material because their understanding of the foundational knowledge needed to comprehend more advanced concepts is flawed.

Through my studies in the Master of Science in Science Education (MSSE) graduate program at Montana State University, I was exposed to a deeper understanding of misconceptions and some of the different instruction and assessment methods designed to help identify and correct them. These included the conceptual change model of instruction and misconception probes.

My experiences led me to the creation of my focus statement: How does the use of misconception probes affect students in the classroom?
1. What affect do misconception probes have on learning and achievement?

2. What affect do misconception probes have on student confidence?

CONCEPTUAL FRAMEWORK

Science can be thought of as a way of learning and knowing about the world. However, it is often presented in educational institutions as a series of facts, theories, and rules to be memorized. According to Piaget, students do not come as blank slates to have knowledge imparted onto; they bring varying sources of knowledge and experience into the classroom with them (Piaget, 2003). The process of taking the knowledge that is imparted to them and combining it with their current knowledge and understandings can sometimes lead to misconceptions about specific scientific concepts or the nature of science itself. Crowther and Price (2014) define misconceptions as inaccurate ideas that predate or emerge from instruction. These misconceptions may impede further learning and cause problems in other concepts as well (Butler, Mooney Simmie, & O’Grady, 2014). To illustrate a common misconception, consider the phases of the moon. Many students who have not been taught about the moon phases believe it is the shadow of the earth falling on the moon that causes the moon’s phases instead of the position of the moon in relation to the sun. This type of misconception could lead to difficulty building a correct understanding of many other astronomical ideas and theories.

Scientific misconceptions are common in the general population. Even those with a science background may be carrying some misconceptions about specific concepts. Butler et al. (2014) found that misconceptions were prevalent even amongst upper-
secondary science students and pre-service science teachers. This is especially worrying because misconceptions that are held by a teacher can be passed on to students.

Since misconceptions are based on the body of knowledge and experience the students bring with them, they have a built-in cognitive support group and defense mechanism that makes them resistant to change, especially through traditional instructional methods. If the misconception is able to predict or explain a phenomenon, the student will see no reason to change. For conceptual change to take place, the students must be confronted with a circumstance or situation that the misconception cannot explain (Guzzetti, Snyder, Glass, & Gamas, 1993). DiSessa (1998) describes two ways that the resulting change can be categorized. The first occurs by making new connections between existing concepts which allows the student to generate new solutions to problems or modify existing solutions. The second type involves the changing of the core concepts themselves, thus changing the systems built upon those concepts. This is categorized as conceptual change.

Duit (2003) described what happens when the learner is confronted with two competing concepts. If they perceive that the competing concept has higher status, then conceptual change can take place. If the old concept is perceived to retain a higher status, then no change will take place. Duit also pointed out, however, that either of these outcomes can revert back, or change at a later time since the replaced conception has not been forgotten. Other studies have found that simply addressing and correcting misconceptions was insufficient to bring about lasting conceptual change. There needs to
be a certain level of student engagement for the process to have the greatest effect (Manolas & Filho, 2011).

Teachers are often exposed to constructivist educational theories in their teacher training or professional development. These theories espouse that knowledge is not something that can be merely imparted to students. Students must be exposed to information, situations, and experiences that will help them to construct their own correct understanding of scientific principles. Research has shown, however, that even a teacher who has training in and philosophically believes in constructivist learning theories is not guaranteed to teach using those methods (Duit & Treagust, 2003; Lemberger, Hewson, & Park, 1999). This may be attributed to how the teacher views the content, the pressures of the course, or their own experience when he or she was a student (Yan Yip, 2004).

Several different instructional strategies exist to help confront misconceptions. Guzzetti et al. (1993) performed a meta-analysis to examine the effects of several different instructional, narrative, and refutation texts as well as various instructional strategies. Their conclusion was that the format of the strategy seemed irrelevant to its success as long as the strategy used caused cognitive conflict. Misconceptions that are held in high confidence may be even more effectively confronted because when a concept that they hold in high regard is challenged, there is increased cognitive conflict. This conflict may cause them to be more interested and engaged in trying to better understand what they were wrong about (van Loon, Dunlosky, van Gog, van Merriënboer, & de Bruin, 2015).
An examination of how multimedia could be used to address misconceptions found that the greatest effects were observed when the video specifically addressed and confronted common misconceptions before giving correct instruction (Muller, Bewes, Sharma, & Reimann, 2008). The most effective method found was when the misconceptions were addressed through a dialog between two people rather than as a lecture type delivery. These results suggest that for instruction to be most effective, it must explicitly address and confront common misconceptions that the learner might have, and that a dialog between the instructor and the students is more effective than direct delivery.

The level of education and experience that a student has in science may also affect the number of misconceptions they have. One study found that the number of misconceptions held by third-year secondary students was fewer than those in their first or second year. This suggests that as students acquire more knowledge and experience, they naturally correct some of the misconceptions that they previously held. Specially designed diagnostic tools can help to successfully identify misconceptions among students and educators so that they can be corrected (Butler et al., 2014).

One method of finding these misconceptions is by the use of small formative assessments to discover the students’ current understanding. Angelo and Cross (1993) refer to this type of tool as a Misconception/Preconception Check. To create a Misconception/Preconception Check, the teacher must first identify the ideas that are most likely to have misconceptions. Then a short questionnaire is developed to uncover where the students’ current understanding lies. Page Keely also developed a similar
instrument she calls a formative assessment probe. In the probe, students must first read an engaging prompt that involves familiar phenomenon or objects. They then choose from a list of explanations that includes the right answer as well as commonly held misconceptions about the phenomenon. The second part requires the student to describe their reasoning, thus deepening their engagement with the probe (Keely, Eberle, & Farrin, 2005). Both of these formative tools provide teachers with a better understanding of what misconceptions the students may hold and their reasoning. The teacher can then provide instruction to help the student build a correct understanding. For the purposes of this paper we will describe these types of formative tools as Misconception Probes.

Once the misconceptions have been identified, then the process of helping students to correct their misconceptions begins. One instructional method that is designed to help build a correct understanding is The Conceptual Change Model, developed by Joseph Stepan in the mid-1980s. It involves guiding students through six different phases to reach a more complete understanding of the concept. First, students must commit to their own ideas about the concept before the lesson. This phase also requires them to be able to describe their reasons why so students are exploring their own thinking. Second, the students share their beliefs with others. This can be done with the teacher, with small groups, or with the entire class. This allows students to become aware of differing beliefs within the class. Third, the students are confronted with an activity, experiment, or other experience that challenges their understanding. Fourth, the teacher facilitates discussion and sharing with the class so students can incorporate the new information and reconstruct their previous conceptions. Fifth, the students are encouraged
to test out their new understanding by making connections to other situations and contexts. Sixth, the students are provided opportunities to extend beyond the learning in the lesson. For example, students may pose questions that need further examination to complete and deepen their understanding (Schmidt, Saigo, & Stepans, 2006).

**METHODOLOGY**

This research project was conducted using one section of high school senior level biology. The class consisted of 16 students, of which five were male, and 11 were female. There were four First Nations/Aboriginal students in the class. The research methodology for this project received an exemption by Montana State University’s Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

This senior high school biology course consisted of four units. One unit focused on the microscopic aspects of biology. Topics covered in this unit included cell division, genetics, and the processes of transcription and translation. Two of the units focused on aspects of human anatomy and physiology. One of them was focused on the body’s internal communication systems. Specifically, this unit covered the structure and function of the nervous and endocrine systems. The other unit focused on the structure and function of the male and female reproductive systems and the processes of human development from conception to birth. The remaining two units were focused on the microscopic and the macroscopic processes of biology. The microscopic unit included mitosis, meiosis, genetics, and transcription and translation. The macroscopic unit covered the study of population interactions and community dynamics. The nervous and
endocrine system units were chosen to be the treatment portion of the study because students were more likely to have some exposure to some of these topics. This prior exposure increased the likelihood that misconceptions may develop. The microscopic biology unit was used as a non-treatment unit. The timing of this project put the other two units outside of the implementation timeframe, so they were not used in this project. For the duration of the study, the same instructional materials were used as had been used in the previous year. The instructional activities and methods were also kept as close as possible to those used in the year previous.

Misconception probes were used to identify student understanding of each concept. Each probe was designed around a scenario and several possible responses to, or interpretations of the information given. One of the provided options was correct while the others contained common misconceptions the students may have had about the concept. After reading the scenario, the students chose the statement with which they most agreed. The students also had to provide, through written response, a justification for their choice. This helps to identify students who may correctly guess the correct choice without having a correct understanding of the concept. The probes were completed during the last 10-15 minutes of class and turned in before the students left class. The results from the misconception probes were analyzed by tallying the number of students who selected each of the response options and by surveying the written explanations that were given to justify their selection. Based on these results, the class received remedial instruction at the beginning of the next class to address their specific misconceptions before moving on to the next lesson.
An example can be seen in J. Graves’ misconception probe on floating paperclips. It presents students with potential explanations of why a paperclip can float on water (personal communication, June 16, 2019). The correct response, because of water’s adhesion and cohesion properties, is presented along with other plausible responses (Figure 1).

Figure 1. J. Graves’ misconception probe on floating paper clips.

In the selected unit, three concepts were identified where students commonly had misconceptions. They were identified by comparing observations from classroom formative and summative assessments with areas that had been identified by exam managers as areas of concern on provincial standardized exams. Two concepts were identified in the endocrine system and one in the nervous system sections of the unit. The concepts addressed and the specific misconception probe that assessed each concept are summarized in Table 1 (Appendix B).

Table 1

<table>
<thead>
<tr>
<th>Concept</th>
<th>Misconception Probe</th>
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<tbody>
<tr>
<td>The antagonistic functions of parathyroid hormone and calcitonin</td>
<td>A Calcium Conundrum</td>
</tr>
<tr>
<td>The different hormonal responses to acute and chronic stress</td>
<td>A Stressful Situation</td>
</tr>
</tbody>
</table>
The impact that external factors or changes in the neuron have on the electrochemical response and nerve signal transduction

At the end of the instruction on the nervous system, and before taking the exam, the students were given the Nervous System Confidence Survey (Appendix C). Students were asked to respond to several “I feel confident...” statements by rating on a four-point scale ranging from Strongly Disagree to Strongly Agree. The survey included statements about specific learning outcomes, and about general confidence levels on the exam. The specific outcomes that were addressed included outcomes that were addressed by the misconception probes and some outcomes that were not.

At the conclusion of the treatment students were given the Misconception Probe Survey (Appendix D). This survey asked students to rate the impact that the individual misconception probes had on their understanding of those outcomes. Students were also asked to rate how the probes affected their overall understanding of the nervous and endocrine systems and what impact they had on their ability to solve complex problems. Three open-ended questions were asked to allow students to give general feedback on their perceived advantages and disadvantages of using misconception probes, as well as any general feedback.

The results from both surveys was examined to compare responses between outcomes and to look for trends. The open-ended responses were reviewed to look for individual insights as well as common themes.
The summative unit exams used were the same ones that had been used in the previous year. The results of the tests were analyzed using the Wilcoxon rank sum test to compare the current class with the past year's class.

Interviews were conducted after the treatment phase with a randomly selected group of five students using the Post-Unit Interview Questions (Appendix E). Other informal conversations with students also occurred, with notes taken alongside classroom observations. All data collection methods are summarized in the triangulation matrix below (Table 2).

Table 2

<table>
<thead>
<tr>
<th>Data Triangulation Matrix</th>
<th>Focus Question</th>
<th>Data Source 1</th>
<th>Data Source 2</th>
<th>Data Source 3</th>
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<tr>
<td><strong>Primary Question:</strong></td>
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<tr>
<td>1. What effect do</td>
<td>Misconception</td>
<td>Summative Exam</td>
<td>Post-test interviews</td>
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<td><strong>Secondary Question:</strong></td>
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<tr>
<td>2. What impact do</td>
<td>Observational</td>
<td>Post-unit surveys</td>
<td>Post-test interviews</td>
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<td>misconception probes</td>
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<td>have on student confidence?</td>
<td>conversations</td>
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DATA AND ANALYSIS

The results from the Calcium Conundrum probe showed that 46% of students were able to successfully choose a statement and provide an appropriate correction to make the statement accurate ($N=13$). Thirty-three percent of those also got the question on the exam that tested this concept correct; while 47% of the students who had misconceptions on the probe were successful on that exam question. 40% of the class got the question right in the treatment group, compared to 38% of students in the previous
year. Several students expressed their lack of deeper understanding. One simply stated, “I don’t know. Forgot some of this stuff.” A desire to work harder in the future was also expressed. One student who could not provide an explanation said, “I promise I will focus more on the hormones from now on. Thank you for not taking this for marks.”

Only 15% of students who completed the A Stressful Situation probe selected the appropriate response. Of those two students, one gave a partially complete, but limited response, and the other student gave an incorrect explanation. Most students correctly explained the physiological effects of epinephrine. The majority of students had the misconception that Adrenocorticotropic Hormone (ACTH) stimulated the release of Epinephrine instead of the sympathetic nervous system. One student focused on the wrong hormone when he stated that, “The possible overload of ACTH may cause stress.” There were no exam questions that directly assessed this topic, so no comparison to past years could be made.

In the nervous system unit, 50% of students chose the correct selection on the A Nervous Mess probe, but only two of those students gave a correct explanation of how the damaged myelin would affect the nerve signal transmission. The most common misconception among students was demonstrated best by one student’s statement that the “sodium gates would be damaged as well” and that damage would cause the signal to slow. On the exam, students scored 69% on the question of what the function of the myelin sheath was, compared to the previous class’ 50% on the same question. However, on a test question regarding the effects of multiple sclerosis, students scored 19% lower than the previous class.
The mean exam marks for the non-treatment cell division and genetics units were similar with decreases of three percent and one percent respectively when compared to previous years class. Statistical analysis showed no significant difference between the results of the two classes (p=0.73, p=0.75). The exam marks in the nervous and endocrine treatment units showed mean values decreased by nine and four percent, respectively (Figure 2). The treatment class was also found not to be significantly different from the previous year’s class (p=0.085, p=0.29).

![Box plot showing exam scores](Image)

*Figure 2. Summative exam scores during the current year and previous year.*

On the Nervous System Confidence Survey given to students before the exam, 53% of students agreed with the statement that they were prepared for the nervous system exam. No concepts that were surveyed had less than 50% student agreement with the confidence statement. The concepts of the role of myelin and the effects of neuron disorders that were covered by the misconception probe were the only specific concepts
that had any students strongly disagree with the confidence statements (Figure 3). Student confidence was found to be moderately correlated with the student performance on the nervous system exam ($R^2=0.65$) (Figure 4).

![Figure 3](image_url) Results of the student confidence survey given prior to the nervous system exam, $(N=15)$.

![Figure 4](image_url) Nervous system exam scores compared to the total confidence score recorded by students on the pre-test survey, $(N=15)$.

On the Misconception Probe Survey 71% of students indicated that the probes had a positive effect on their overall understanding of the unit $(N=14)$. The results of the individual probes varied (Figure 5). Forty-two percent of students responded that the
Calcium Conundrum probe had a positive effect on their understanding while 25% felt it had a negative effect. A greater percentage of students found the other probes helpful. On the Stressful Situation Probe 85% of students reported that the probe had either a positive effect or very positive effect on their understanding of the concept of hormonal stress response while only one student reported it having a very negative impact. The Nervous Mess probe showed that 64% of students found this probe had a positive effect on their understanding, while only 21% indicated its impact was negative.

**Figure 5.** Student responses to the Misconception Probe Survey.

Students reported the advantages of doing misconception probes. The first was the chance to interact with the material on a deeper level. One student mentioned that it “helps apply what we have learned.” Another student said they, “enjoyed being wrong and learning the right way.” The second major theme seemed to center around the idea that the misconception probes led to a better metacognitive understanding of where the students were at in respect to the material. As a student put it, “When trying to explain, I find that I really come to realize what I know and [what I] don’t.” Another student
described it as a chance to, “see what I don’t know and correct [it] before I solidify a bad piece of information.”

Students also identified some disadvantages of using misconception probes. The most commonly mentioned idea was that some students might “get upset about being wrong and then not learn from it.” Alternatively, another student said the probes, “could leave students more confused than they were already.” These concerns are also validated by personal observations that some students who struggled on the probes were not willing to put in extra time if the in-class discussion of the probe did not help their understanding. They seemed to withdraw rather than to engage more fully.

A comparison of the survey results on student opinions and the students’ performance on the summative exam revealed a strong negative correlation between the number of students who were correct on the misconception probe and the impact students felt the probe had on their understanding ($R^2 = -0.87, N=3$) (Figure 6).

![Figure 6. Comparison of the number of students who were initially correct on the misconception probe, and the percent of students who felt the probe had a positive impact on their understanding, (N=3).](image-url)
The primary question of this research was to find what affect misconception probes would have on learning and achievement. It was observed that the misconception probes had a greater benefit to those students who could not identify the correct statement or correctly explain their reasoning. Students who were not challenged by the probe may not have paid as close of attention or engaged with the discussions after the probe. This is also observed in the negative correlation between the number of students who responded correctly in their choice and explanation, and the number of students that reported the probe had a positive impact on their understanding. The more challenging the probe was, the higher the cognitive discontent and the greater the engagement with the remedial instruction.

The treatment units where misconception probes were used did not see a significant change in exam scores. Although not significant, there were decreases in mean and quartile scores between the treatment units compared to the previous year’s performance on the same exams. This result may be a result of the misconception probes, or it may be due to the high number of interruptions and absences that occurred during the instruction of these units which was higher than it was during the non-treatment units.

The misconception probes also facilitated greater metacognitive awareness. The only concepts identified by students on the post-unit confidence survey as “strongly disagree” were the topics covered by the misconception probes. There were other topics listed on the same survey that have a similar level of difficulty and rigor, but students did not identify as strongly with these topics. It is possible that the higher level of
understanding required to answer the misconception probes successfully led to this deeper realization about what the students actually understood.

This metacognitive awareness is also linked to the secondary purpose of this study to find what impact misconception probes have on student confidence. While it did not translate directly to performance on the summative exam, most student’s confidence increased as a result of the probes. The majority of students responded that the probes had a positive impact on their understanding. This conclusion is supported by the open-ended survey responses and the statements given by students in the interview. This is not true of all students. Some students may have been negatively affected by the misconception probes. This can be seen in the concern raised in the survey that some students may become even more confused or too upset to continue. It may also be evidenced by the lower exam scores during the treatment units, but it is difficult to know if this was the result of the treatment or the other distractions and circumstances at the time. This negative effect does seem to be limited to a small percentage of students; however, it is still a point of concern.

VALUE

Misconceptions are a part of life. In science, they are becoming more and more prevalent due to factors such as the polarization of political policy on scientific theories, social media and the spread of pseudoscience, and television along with movies and other main-stream media sources. Students will continue to arrive in classrooms with ever more entrenched misconceptions, especially those that have political or social implications. Teachers need to have a grasp of those tools and strategies that can help
them to identify these misconceptions and then to help students to come to a correct understanding of the scientific principles involved.

Misconception probes can be part of a broader formative assessment strategy and instructional plan. They allow teachers to identify the misconceptions within a classroom population and then formulate a plan to break down those misconceptions and to guide students to a solid scientific foundation for their growing knowledge. When I began this capstone project, I was hoping study the effect of different instructional methods designed to combat misconceptions; however, changes in teaching load and class assignments made this too difficult to carry out in this capstone. I do want to address still the questions of how strategies such as the 5E method, and others can impact student misconceptions with future study in my classroom.

This project has also shown that misconception probes may have a negative impact on some students. Care needs to be taken that students who are struggling or who are lacking in confidence are not allowed to slip through the cracks or to be content with a lack of understanding. Once the misconceptions are identified, they need to be addressed in a way that will help all students increase their understanding. This further emphasizes the need for appropriate instructional strategies to remove misconceptions and help students to achieve a greater understanding of the world.

The greatest value for me has come as a result of the circumstances surrounding my project. If I may explain, this was initially intended to be carried out in a chemistry classroom, then it was changed to a junior level biology, and finally a senior level biology class. Then on the first day of the semester, my teaching load changed from two
sections of the same class down to a single class of just 16 students. I had planned to use
the two classes as non-treatment and treatment groups, alternating between the two
classes. This would have facilitated a better comparison and more rigorous statistical
analysis, but that is the reality of teaching sometimes. Circumstances and assignments
can change at the drop of a hat. Those changes have left in me a desire to do further
projects to examine the impact of the teaching strategies that I had to remove from the
project this time due to time constraints.

Meaningful research does not always have to provide answers to questions;
sometimes it can simply lead to better questions. One of the main areas I feel myself
drawn to now is the negative correlation I observed between the number of students who
were initially correct on the misconception probe and the value the students found in it.
Why did the students find more value in the more difficult probes? Most students do not
naturally find benefit in failure or in challenging thought assignments. Could these
positive experiences with an initial failure help to build resiliency in students? Could
these experiences help to foster a growth mindset in students? It certainly has in me.
REFERENCES CITED


APPENDICES
APPENDIX A

INSTITUTIONAL REVIEW BOARD EXEMPTION
MEMORANDUM

TO: Murry Scott Quinton and John Craver

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

DATE: March 18, 2019

RE: "Using Misconception Probes in the Study of Human Anatomy and Physiology" [MQ031819-EX]

The above research, described in your submission of March 18, 2019, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

   (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.

   (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.

   (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

   (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.

   (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.

   (b) (6) Taste and food quality evaluation and consumer acceptance studies, if (i) 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, 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

MISCONCEPTION PROBES
A Calcium Conundrum

You are studying with a group of students for an upcoming exam. You are having a discussion about how the body responds to changes in homeostasis. You begin to have a disagreement about how the body would respond to high blood calcium levels. Each person has their own opinion.

Jake: Parathyroid hormone would be released from the parathyroid gland

James: thyroxine would need to be released from the thyroid

Susan: Calcitonin would be released from the parathyroid gland

Mark: Parathyroid hormone and calcitonin would both need to be released

************

You may not agree with any of them completely, but Who do you agree with most? _________

If you didn’t agree completely, how would you correct their statement?

__________________________________________

Explain how the released hormone(s) would affect blood calcium levels?

__________________________________________

__________________________________________

__________________________________________

__________________________________________

__________________________________________
A Stressful Situation

Mike is stressing about exams, work, and the really cute girl he sits next to in his English class. It has been like this for weeks. He has been having trouble sleeping and has even been losing weight. Trying to make the best of a tough stretch he is studying with some of his friends. They are trying to understand how the endocrine system responds to stressful situations. Each person tries to give their best explanation of what is happening to Mike.

Jill: I think that your ACTH levels are likely very high, and they are stimulating you to release too much epinephrine which is overworking the body.

Randy: I think that you don’t have enough epinephrine. If you did, your body would be able to adapt to the stress. That is what epinephrine is for.

Peter: I agree with Jill that your ACTH levels are probably high, but that would result in high levels of Aldosterone and Cortisol. That is what is causing the strain on your body.

************

Which of Mike’s friends do you agree with most? ________________

Explain how the release of the hormone(s) the friend mentioned would affect the body? How would they lead to his symptoms?

_________________________
_________________________
_________________________
_________________________
_________________________
A Nervous Mess

You have been so excited to learn about the nervous system that you have been reading extra material and doing your best to learn the material. You have read about Multiple Sclerosis, an autoimmune disease that attacks the myelin sheath. You and some friends are discussing what impact the loss of myelin would have on the neuron.

Jill: the damage to the myelin sheath would make the impulses travel slower because the impulse could not travel through the damaged myelin as fast as it could through healthy myelin.

Paul: the damage to the myelin sheath would make the impulses travel faster because without the insulating effect of the myelin there would be less to slow them down.

Will: the loss of myelin would affect the transmission of nervous signals at the synapse. The acetylcholine produced by the myelin would be missing or inadequate to transmit the signal to the post-synaptic neuron.

Jean: nerve signal transmission would either slow or possibly stop depending on the level of damage. This is because so many more sodium gates would have to be stimulated to threshold all along the axon of the neuron.

**********

Which of your friends do you agree with most? _________________

Explain why you most agree with that friend, and add in any details they may be missing.

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________

_________________________________________________________________________
APPENDIX C

NERVOUS SYSTEM CONFIDENCE SURVEY
Nervous System Confidence Survey

Participation in this research is voluntary and participation or non-participation will not affect a student’s grades or class standing in any way.

Name:________________________

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<tbody>
<tr>
<td>1.</td>
<td>I feel confident that I am understand the different divisions of the nervous system.</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Strongly Disagree</td>
<td>SD</td>
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<td>2.</td>
<td>I feel confident that I know the anatomical structures of a neuron and the roles each structure plays.</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
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<td></td>
<td>SD</td>
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<td>3.</td>
<td>I feel confident that I understand the specific role that myelin plays in nerve signal transmission.</td>
<td>1</td>
<td>2</td>
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<td>5</td>
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<td></td>
<td>SD</td>
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<td>4.</td>
<td>I feel confident that I can determine how a disorder will affect the nervous system if I know what the disorder changes in/on the neuron.</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
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<td>SD</td>
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<td>5.</td>
<td>I feel confident that I understand the concept of threshold.</td>
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<td>2</td>
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<td>5</td>
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<td></td>
<td>SD</td>
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<tr>
<td>6.</td>
<td>I feel confident that I can predict the nervous system’s responses to changes in homeostasis.</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
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<td>SD</td>
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<td>7.</td>
<td>I feel confident that I understand the components and function of a reflex arc.</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
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<td></td>
<td>SD</td>
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<td>8.</td>
<td>I feel confident that I am prepared for the nervous system exam.</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>5</td>
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<td></td>
<td>SD</td>
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APPENDIX D

MISCONCEPTION PROBE SURVEY
# Misconception Probe Survey

Participation in this research is voluntary and participation or non-participation will not affect a student’s grades or class standing in any way.

**Name:**

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<tbody>
<tr>
<td>1.</td>
<td>What impact did the misconception probes have on your overall understanding of the Nervous and Endocrine Systems?</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td></td>
<td>Very Neutral Very Positive</td>
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<td></td>
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<tr>
<td>2.</td>
<td>What impact did the “A Calcium Conundrum” probe have on your understanding of calcitonin and parathyroid hormone functions?</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>3.</td>
<td>What impact did the “A Stressful Situation” probe have on your understanding of the body’s long and short-term stress response?</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>What impact did the “A Nervous Mess” probe have on your understanding of nerve signal transduction and myelin’s function?</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<tr>
<td>5.</td>
<td>What impact did the misconception probes have on your ability to solve complex problems?</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>6.</td>
<td>What do you see as the biggest benefit of doing misconception probes?</td>
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<tr>
<td>7.</td>
<td>What do you see as the biggest negative aspect of doing misconception probes?</td>
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<tr>
<td>8.</td>
<td>What other information would you like me to know about your experience with the misconception probes in this unit?</td>
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</table>
APPENDIX E

POST-UNIT INTERVIEW QUESTIONS
Post-Unit Interview Questions

Participation in this research is voluntary and participation or non-participation will not affect a student’s grades or class standing in any way.

1. How did the misconception probes influence your learning of endocrine concepts?
2. How did the misconception probes affect your confidence going into the test?
3. What misconceptions did you have that were hardest to reexamine? why was it difficult? Where did your misconception arise from?
4. What do you think might help future students to keep from developing misconceptions?
5. What do you think might help future students to change their misconceptions?