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Efficacy Of Mastery-Based and Autonomy-Supportive Neuroanatomy Curriculum in Graduate Level Human Neurobiology Course

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EFFICACY OF MASTERY-BASED AND AUTONOMY-SUPPORTIVE NEUROANATOMY
CURRICULUM IN GRADUATE LEVEL HUMAN NEUROBIOLOGY COURSE

A thesis submitted in partial fulfillment of the requirements for the degree of Master of
Science

By

CORIN WOLFGANG MAGEE
B.S., Wright State University, 2012

2015
Wright State University

WRIGHT STATE UNIVERSITY

GRADUATE SCHOOL

April 27, 2015

I HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER MY SUPERVISION BY Corin Wolfgang Magee ENTITLED Efficacy of Mastery-Based and Autonomy-Supportive Neuroanatomy Curriculum in Graduate Level Human Neurobiology Course BE ACCEPTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF Master of Science.

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ABSTRACT

Magee, Corin Wolfgang. M.S. Department of Neuroscience, Cell Biology, and Physiology, Wright State University, 2015. Efficacy of Mastery-Based and Autonomy-Supportive Neuroanatomy Curriculum in Graduate Level Human Neurobiology Course.

Anatomy provides scientists with a common vocabulary for discussing the human body, and is, therefore, an important aspect of science education. Literature shows that traditional teaching methods may be enhanced by the employment of mastery-based learning in an autonomy-supportive environment. The present study sought to determine the effects of these teaching strategies on the learning of neuroanatomy in a graduate neurobiology course.

These results show students learned and reportedly enjoyed learning a large amount of neuroanatomy. Experimentally taught students who completed the curriculum did well on the 30-item neuroanatomy quiz (mean score 81%), which was administered at the end of the 16-week semester. Administration of a modified Intrinsic Motivation Inventory (IMI) revealed students felt relatively competent, interested, and unpressured (average rating of 5 out of 7) while studying neuroanatomy.

They did not report high levels of perceived choice (3/7). We believe these teaching methods should be employed in more courses.

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Dedication

This thesis is dedicated to my Lord in Heaven. Please, **let my teaching fall like rain and my words descend like dew, like showers on new grass, like abundant rain on tender plants.**

- Deuteronomy 32:2

I. Introduction

Anatomy provides scientists a common vocabulary for discussing the human body. For that reason, all medical professionals must be comfortable using anatomical terms that are learned in post-secondary or professional schools. In teaching anatomy or any scientific concept it is critical that teachers practice the most efficient instructional techniques possible; any improvement could have a significant impact on the quality of patient care and the advancement of scientific knowledge. Evidence found in the literature suggests current methods of scientific training could be enhanced by the utilization of an autonomy-supportive and mastery-based curriculum.

Autonomy gives students the freedom to study what they want to learn. This desire leads to increased levels of effort, performance, intrinsic motivation, creativity, and satisfaction with the learning process (O'Donnell, Chang, & Miller; Grolnick & Ryan, 1987; Deci, Vallerand, Pelletier, & Ryan, 1991; Kinzie & Sullivan, 1989; Patall, Dent, Oyer, & Wynn, 2013; Standage, Duda, & Ntoumanis, 2006; Vazou-Ekkekakis & Ekkekakis, 2009; Vansteenkiste, Simmons, Lens, Deci, & Sheldon, 2004; Savard, Joussemet, Pelletier, & Mageau, 2013; Amorose & Anderson-Butcher, 2007). Additionally, students learn how to manage time, be independent learners, and set their own goals and deadlines.

Taking a mastery approach to learning is important because it has been shown most students are capable of achieving high levels of performance and understanding if given enough time and support (Bloom, 1984). Everyone is allowed to learn at their own individual pace, whether fast or slow, until they fully understand whatever subject they are studying. Such a strategy allows everyone to master material in every class they take, including anatomy.

The primary goal of this study is to examine the efficacy of an autonomy-supportive and mastery-based approach to teaching anatomy compared to traditional teaching methods. This will be done by employing these instructional techniques to teach the neuroanatomy portion of a master's level neuroscience course, then comparing test scores with that of the previous year's cohort. We expect that our results will be consistent with those of previous studies, with students showing a deeper understanding of anatomy and displaying a greater enjoyment for the learning process.

Intrinsic Motivation

Intrinsic motivation is the motivation to do things for their own sake. It is an important concept because its presence is correlated with increased levels of interest, performance, conceptual understanding, creativity, satisfaction, and confidence in learning. For example, in a study of 327 architecture students, it was shown that intrinsic motivation was shown to be an important factor in experiences of flow (a state of intense focus and enjoyment) during academic activities (Fullagar & Mills, 2008).

Therefore, if we want to maximize the effectiveness of anatomical education, we must create a learning environment which nurtures intrinsic motivation. This can be done by providing for everyone's basic psychological needs of competency (mastery) and autonomy (freedom) (Deci, Vallerand, Pelletier, & Ryan, 1991; Ryan & Deci, 2000).

Everyone is different; therefore, everyone's optimal learning environment may be different. We must give students some autonomy to determine how they can best interact with their environment in order to maximize their learning experience. In fact, literature shows when students are given some control over their instruction, they can achieve a greater amount of learning in the same amount of time (Kinzie, Sullivan, & Berdel, 1988). This is beneficial because the more students achieve within a particular subject, the more they will come to enjoy that subject (Williams, Wiener, Markakis, Reeve, & Deci, 1994). Conversely, if students do not achieve a sense of competency within their academic domain, they will eventually move on to others (Drew, 2011). They must be given full opportunity to develop and demonstrate their mastery of course materials. Providing students with autonomy will better enable them to achieve competence, increasing their levels of intrinsic motivation for learning. The following sections highlight literature dealing with the facilitation of intrinsic motivation through the satisfaction of these basic needs.

Mastery

Students derive feelings of pleasure from their command of abilities which they are naturally inclined to develop. The process of development is like running a

marathon. Some participants may need more time than others; however, most are capable of crossing the finish line eventually. Aptitude for a subject determines the rate at which learning will occur, not the complexity of ideas that can ultimately be attained.

Benjamin Bloom, author of Bloom's taxonomy, believed that at least 95% of students were capable of achieving an "A" level understanding of any subject if given sufficient time, support, and help. In fact, it has been shown that 90% of students receiving private tutoring attain the same level of achievement as the top 20% of students undergoing traditional classroom instruction (Bloom, 1984). He and his graduate students were also able to identify multiple methods of group instruction as effective as private tutoring. These included: combining mastery learning with enhanced pre-requisites to enroll in the course; combining mastery learning with a focus on higher mental processes such as problem solving and creativity; combining mastery learning with enhanced explanations, student participation, and reinforcement; and utilizing enhanced cues and participation in a traditional setting. Nordin, creator of this last instructional technique, later found that mastery learning worked better than his original method (Bloom, 1984). Bloom concluded the feelings of competence developed through mastery learning are important for mental health, and achievement of mastery leads to enhanced motivation and a lifelong desire for learning (Bloom, 1971).

Many other benefits of mastery-based learning have been described. Shu Liao, Associate Professor of Accounting at U.S. Naval Postgraduate School in 1978, found that students in a self-paced accounting course achieved higher test scores, enjoyed the

flexible course structure, and were more likely to drop out if they were lacking self-motivation (Liao, 1978). He proposed this instructional method may be an effective tool for separating the “curious from the serious.” Leona Leblanc, assistant professor in the Department of Modern Languages of Florida State University in Tallahassee, said about her self-paced French course:

What we have seen so far in this self-paced program is exciting. The students receive considerably more attention, score higher on departmental exams and on achievement tests and rate their instruction as superior to that of more conventional classes. Greater freedom in choosing subject matter, many opportunities to do well on objectively defined assignments, the probability of superior students' completing work in much less time, using media to enliven class while freeing the instructor from repetitive tasks: these are the building blocks of our program. Faculty members at all levels of education face ever greater challenges as they work to create and maintain participatory instruction while enrollments are uncertain and budgets are cut. The many possibilities offered by self-paced programs that are effective and satisfying are just the tools these teachers need. The successful features of this language learning program can be adopted by colleagues in many fields. Our problems are strikingly similar, and the solutions may be, surprisingly, the same. (LeBlanc, 1992)

If we want all of our students to attain high levels of competency, we must utilize mastery learning. All of our graduates should be highly capable. No one is satisfied with

an electrician who can only wire 90% of their house. They must be able to turn on all of the lights.

Autonomy

Literature shows that mastery-based learning is more effective in autonomy-supportive environments. In a study of 117 college students, results showed that mastery goals led to more positive emotional experiences when given in an autonomy-supportive context relative to one that was either autonomy-suppressive or autonomy-neutral (Benita, Roth, & Deci, 2013). In a study of 839 7th and 8th grade students, results revealed stronger relations of mastery goals with interest and enjoyment and with behavioral engagement when students perceived their level of choice (experience of autonomy) as high rather than low (Benita, Roth, & Deci, 2013). Three experiments involving high school and college students examined the role of goals (Intrinsic vs. extrinsic) and learning environments (autonomy-supportive vs. controlling) on learning of physical exercises and text materials. Results showed that both variables had main effects on depth of processing, test performance, and persistence. Further, when intrinsic goals were present in an autonomy-supportive environment, deep processing and test performance were greatly enhanced (Vansteenkiste, Simmons, Lens, Deci, & Sheldon, 2004).

Limitations of Traditional Instruction

Often times, students do not appear to be interested in learning. This causes teachers to employ controlling teaching methods (rewards, punishments, competitions,

etc...). However, research shows that these practices further inhibit most pupils' intrinsic desire to learn. Indeed, it has been shown that when 4th graders are exposed to teachers who use controlling teaching styles in order to increase test scores, they experience performance impairment (Flink, Boggiano, & Barrett, 1990). Individuals have also been shown to be more interested in word games after being exposed to them in the absence of a completion deadline, as compared to those who were given a time limit (Amabile, Dejong, & Lepper, 1976). In a study of seventy-eight undergraduate students, exposure to controlling teaching styles correlated with a relative increase of cortisol levels, whereas exposure to autonomy-supportive teaching styles correlated with a relative decrease in cortisol levels (Reeve & Tseng, 2011). In this section I am going to describe some methods of traditional teaching that can be controlling and, therefore, are counter-productive to real learning.

Grades

Grading or other ranking strategies are ubiquitous in education, but are one of its most destructive practices. Grades can be perceived as nothing more than bribes and threats. If a student performs well, he is rewarded with an "A." If a student performs poorly, he is punished with an "F." This system is thought to promote academic excellence by encouraging hard work. This could not be further from the truth. In this section I am going to further discuss the effect of grades on learning.

For students with performance goals, students who study in order to earn an "A" (performance-approach) or avoid being given an "F" (performance-avoidance), grades inhibit intrinsic motivation to learn. In a study of 361 college students, it was found that

grades only increased the motivation of students with mastery goals, while they decreased the motivation of students with performance-avoidance goals, and, if they scored poorly, decreased the motivation of students with performance-approach goals. These results were consistent when students' perceptions of success were examined in place of grades (Shim & Ryan, 2005).

Students who are externally motivated by grades begin to study in order to earn an "A." They are not interested in mastering the subject. They shy away from challenging material that may hinder their ability to score well. Their learning ceases when the opportunity to earn a grade is removed. These students show decreased intrinsic motivation after receiving low grades (Elliot, 1999). Further, a meta-analysis of 128 studies showed that all types of extrinsic rewards significantly decreased intrinsic motivation and self-reported interest (Deci, Koestner, & Ryan, 1999).

Grades serve as punishments for low scoring students. These students begin to develop feelings of helplessness. They give up on schooling because they cannot achieve passing grades. These failures lead many students to believe that they are not capable of learning difficult subjects, such as science and mathematics. Indeed, 60 percent of students intending to pursue STEM majors never complete their studies. The combined attrition rate of all other majors is 30 percent (Drew, 2011).

Grades do not necessarily reflect how well a student understands a subject. They only show how a student performed on a particular test, on a particular day, in a particular class. Maybe: he/she was sick or distracted by other circumstances; there was

a language barrier, on the part of the teacher or student, which made reading the test questions difficult; he/she is a good guesser; the teacher curved the grades up or down because the original average was too high or too low; the test was impossibly hard or ridiculously easy; the student has improved his/her knowledge of the material since receiving the low grade; the student has forgotten nearly everything that was tested and could no longer achieve a passing grade; the student accidentally filled in the wrong bubbles.

Why do we bother to identify knowledge gaps if we are not going to help them improve? When will they have time to re-study old material if the class is moving on to other topics? Why should they review misunderstood concepts if there is no opportunity to receive credit for knowledge gains and there is new material being presented? How will they comprehend more advanced concepts if they do not understand those which came before?

Competitions

Competitions are used extensively in education as a way to enhance student motivation and performance. However, research shows that competition undermines intrinsic motivation, leading to decreased levels of performance. While working on puzzles, some subjects were told to complete them faster than their partner, whereas some were told only to complete them as quickly as possible. Those who competed showed a significant decrease in intrinsic motivation for the puzzles (Deci, Betley, Kahle, Abrams, & Porac, 1981).

Competition teaches students to derive their self-worth from comparison with others (Ames, 1984). They can only feel good about themselves if they can prove superiority over their classmates. Comparatively low-performing students come to view themselves as being less valuable people. This leads to frustration, depression, and feelings of worthlessness. Additionally, many associate competitions with increased levels of anxiety caused by fear of failure or uncomfortableness with trying to make others lose.

In summary, anatomy provides scientists with a common vocabulary for discussing the human body, and is, therefore, an important aspect of science education. Literature shows that traditional teaching methods may be enhanced by the employment of mastery-based learning in an autonomy-supportive environment, and by the cessation of teaching practices which can be perceived as controlling. The present study seeks to determine the effects of these teaching strategies on the learning of neuroanatomy in a master's level human neurobiology course.

II. Methods

Instructional Material

A neuroanatomy notebook was generated and used as the primary tool used to teach anatomy. It consisted of approximately 200 neuroanatomical terms which were subdivided into 5 laboratories: laboratory 1 covered basic directional terms and anatomical concepts, laboratory 2 covered gross anatomy of the cerebrum and its functional areas, laboratory 3 covered ascending and descending tracts and anatomy of the spinal cord, laboratory 4 covered the anatomy of the basal ganglia and cerebellum, and laboratory 5 covered the blood supply of the brain and spinal cord (see appendix A). Resources available to the students to aid in their learning of neuroanatomy included: numerous textbooks and atlases, instructors, prosections, and a series of PowerPoint slides were also compiled (see figure 1). In order to support autonomy, the students were allowed to complete the laboratories at any point during the semester, and in any order they desired, all designated laboratory periods were optional.

Assessments

In order to receive credit, students were required to correctly identify (on prosections) and explain the major functions of all of the structures contained within a

given laboratory. They were given an unlimited number of attempts to do this; failures were not recorded and did not count against them in any way.

Students who had mastered a given laboratory were allowed to evaluate and give credit to their peers on that same laboratory. Students who were evaluated by the graduate teaching assistant (GTA) on a given laboratory were considered to be in the 1st generation of that laboratory's pedigree. Likewise, students who were evaluated by a peer in the 1st generation were considered to be in the 2nd generation of that laboratory's pedigree, and so on.

At the end of the semester, students were given an anatomy quiz composed of questions which had been administered to the traditionally taught cohort, and a modified version of the Intrinsic Motivation Inventory (IMI) to determine their levels of intrinsic motivation for the study of neuroanatomy (Ryan & Deci).

III. Results

The aims of the present study were to develop an autonomy-supportive neuroanatomy curriculum, and then to determine whether it resulted in student learning and enjoyment. This section will discuss the assessments of its efficacy.

Completion and Peer Evaluation

Most of the teaching and evaluating was performed by the students; the graduate teaching assistant (GTA) only proctored 37% of the completed laboratories. In laboratory 2, for example, the GTA evaluated 7 students, 5 of which continued on to evaluate one or more of their peers (see figure 2). 23% of the students completed the entire curriculum without being evaluated by GTA. 82% of the students proctored at least one of their peer's laboratories. Some laboratories continue to the 5th and 6th generations.

Autonomy

In order to foster a sense of autonomy, students were given the freedom to complete the laboratories in any order and at any time throughout the semester. We recorded the rate of class progression in each of the laboratories and have displayed them in cumulative histograms (see figure 3).

Laboratories 1 and 2 had been completed by about 90% of the class by the end of the second week. Laboratories 3 and 4 were completed by the majority of students between the middle of November and the first week of December and only reached 95% completion. Laboratory 5 had been completed by about 50% of the class by mid-October and was completed during the first week of December.

General assessment of neuroanatomical knowledge

In order to determine how well the students had learned neuroanatomy, we administered a 30-item neuroanatomy quiz during the final week of the semester. It did not count as a part of the students' final grade and participation was optional. There were 20 questions over material from laboratory 2 and 3 questions each for laboratories 3, 4, and 5. Question 18 could have been answered using knowledge from multiple laboratories, so it was not included in any analyses of performance on individual laboratories.

All of the students who took the 30-item quiz (n=17) averaged a 74%, those who had completed the entire curriculum prior to the quiz (n=13) averaged an 81%, and those who had completed the entire curriculum and evaluated at least one of their peers prior to the quiz (n=9) averaged an 85% (see figure 4).

On the 20 question laboratory 2 sub-quiz, all of the students (n=17) averaged a 73%, those who had completed the entire curriculum prior to the quiz (n=13) averaged a 78%, and those who had completed the entire curriculum and proctored at least one of their peers prior to the quiz (n=9) averaged an 87% (see figure 5).

We also analyzed generational performance on the whole neuroanatomy quiz (see figure 6) and on each of the laboratory sub-quizzes (see figures 7 and 8). On the laboratory 2 sub-quiz, the first generation of the laboratory 2 pedigree averaged an 83%, the second generation averaged a 71%, and the third generation averaged a 68%. The average 30-item quiz score for the first generations of all four laboratories was a 90%, the second generations averaged a 78%, and the third generations averaged a 72%.

Performance comparisons

The first 21 questions of the neuroanatomy quiz were taken directly from various examinations given to the previous year's traditionally taught course. We have compared performance between the two cohorts on these 21 items (see figure 9), and on subsets of these questions belonging to specific laboratories (see figure 10). Question 18 could have been answered using knowledge from multiple laboratories, so it was not included in any analyses of performance on individual laboratories.

On the 21-question quiz, the traditional cohort (n=20) averaged an 81% and the experimental cohort (n=17) averaged an 80%. All members of the experimental cohort who had completed the entire curriculum prior to the quiz (n=13) averaged an 81%, and those who had completed the entire curriculum and evaluated at least one of their peer's laboratories prior to the quiz (n=9) averaged an 85%.

On the 11 question laboratory 2 sub-quiz, the traditional cohort (n=20) averaged an 89% and the experimental cohort (n=17) averaged a 74%. All members of the

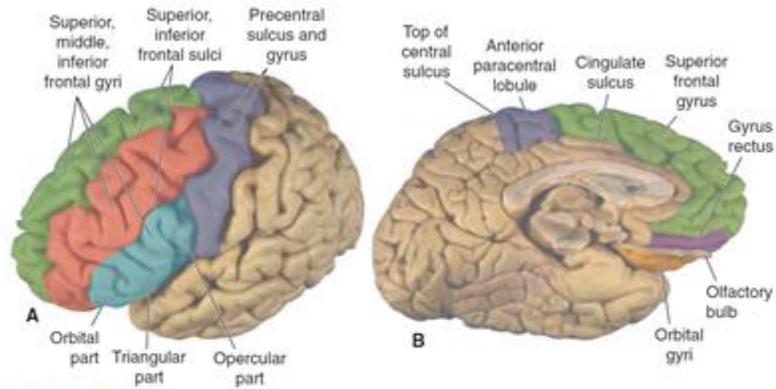
experimental cohort who had completed the entire curriculum prior to the quiz (n=13) averaged a 78%. Those who had completed the entire curriculum and evaluated at least one of their peer's laboratories prior to the quiz (n=9) averaged an 87%.

Assessment of enjoyment

To help determine whether or not the students were intrinsically motivated for the curriculum, we administered a 22-item self-report measure of intrinsic motivation, the Intrinsic Motivation Inventory (IMI) (Ryan & Deci). The IMI consists of four subscales: perceived interest (intrinsic motivation), perceived confidence, perceived choice, and perceived pressure. Students read statements (e.g. Doing the anatomy labs was fun.) and assigned them a score on a scale of 1 (not very true) to 7 (very true). The statement scores were then averaged to give subscale scores (see figure 11). Students scored perceived interest and confidence close to a 5, perceived choice about a 3, and perceived pressure around 2.5.

Figure 1

Example – Lab 2



Subdivisions of Frontal lobe

- Precentral gyrus and sulcus
- Superior, middle, and inferior frontal gyrus
- Anterior paracentral lobule
- Superior and inferior frontal sulci

Image taken from
NoIt

Figure 1. This is an example of resources available for laboratory 2. Students would use the neuroanatomical terms list (bottom) to determine which structures they needed to identify on pictures (top) and prosections.

Figure 2

Laboratory 2 Pedigree

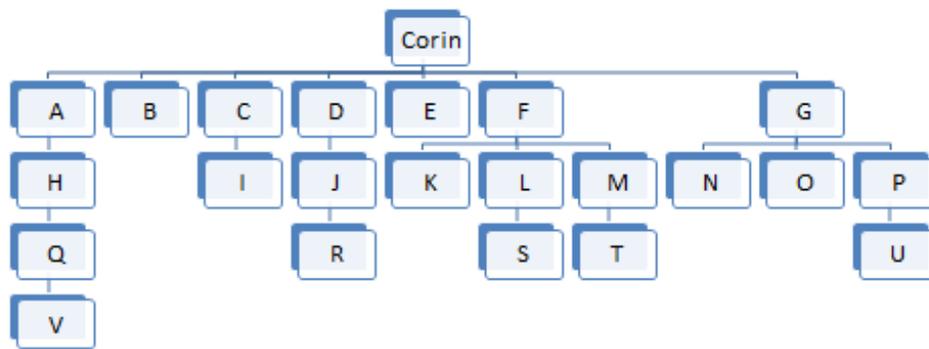
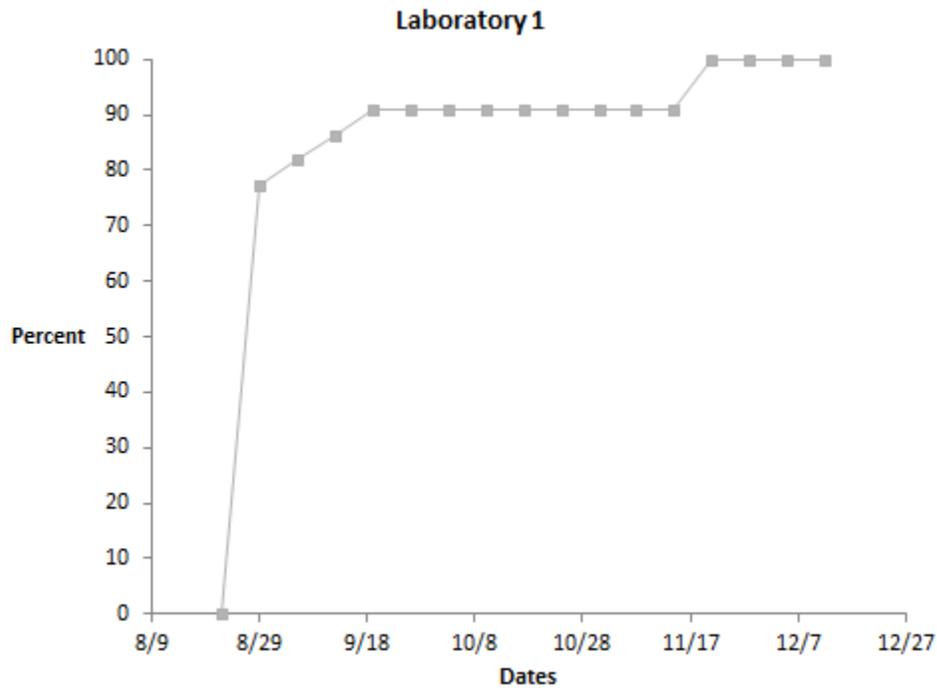


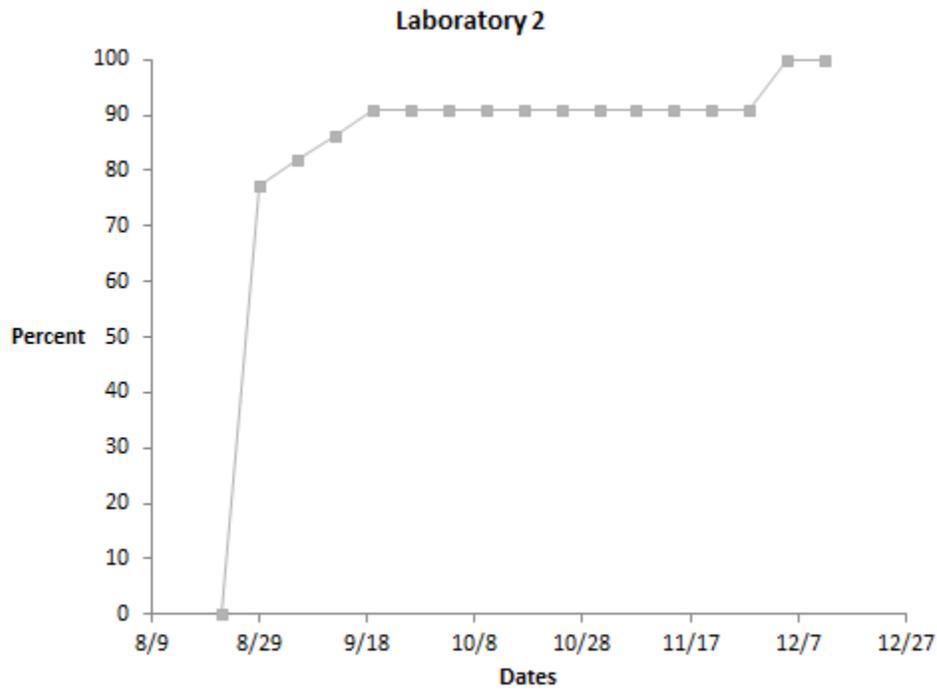
Figure 2. This pedigree shows the lineage of information transfer for laboratory 2 from the graduate teaching assistant to the students in the 1st (A-F), 2nd (H-P), 3rd (Q-U), and 4th (V) generations. Student names have been replaced with single letter abbreviations.

Figure 3

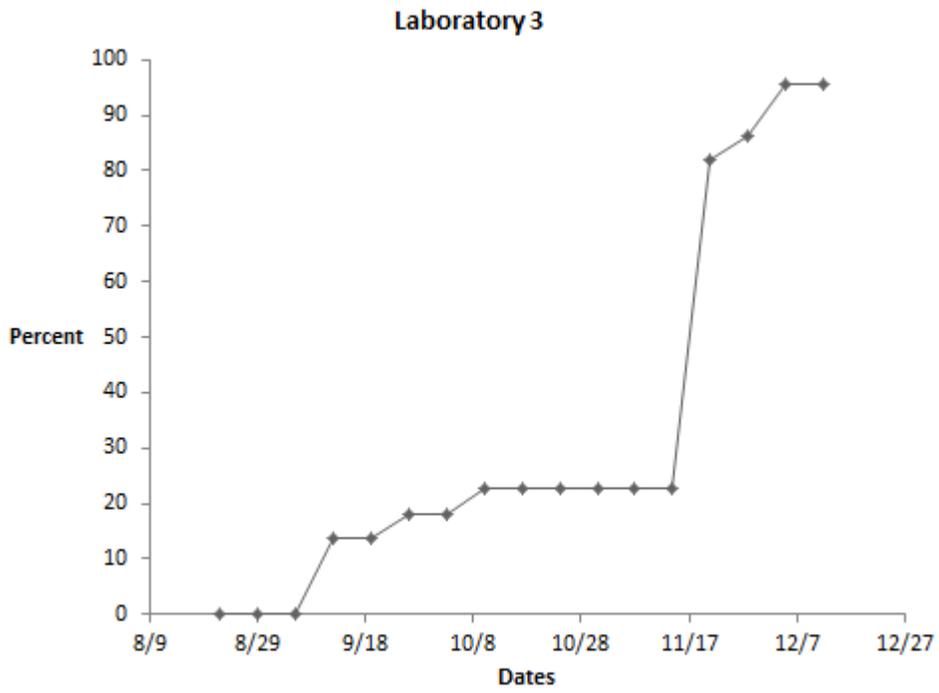
A.



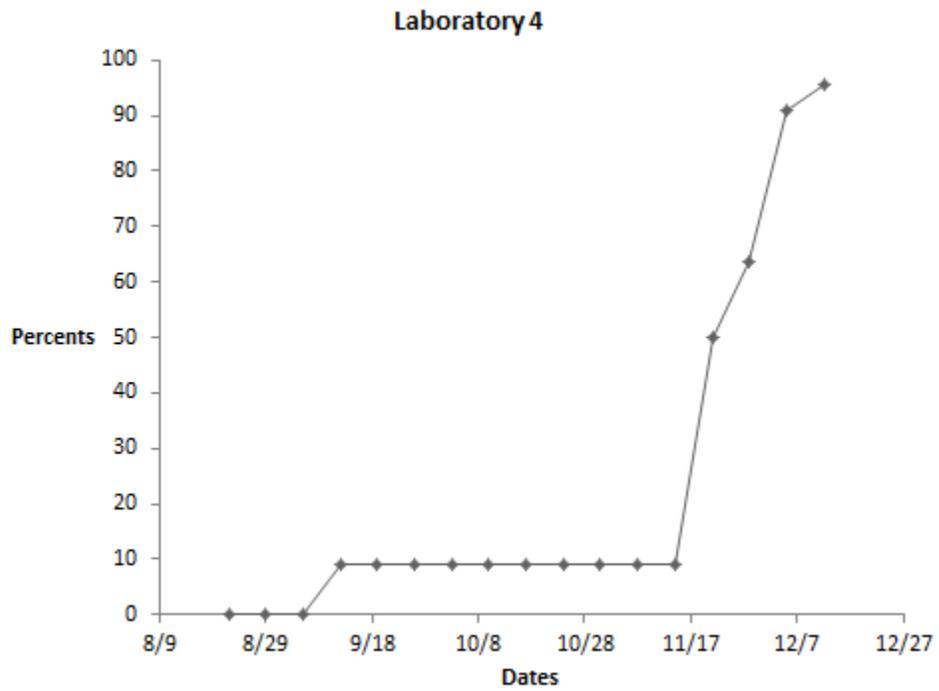
B.



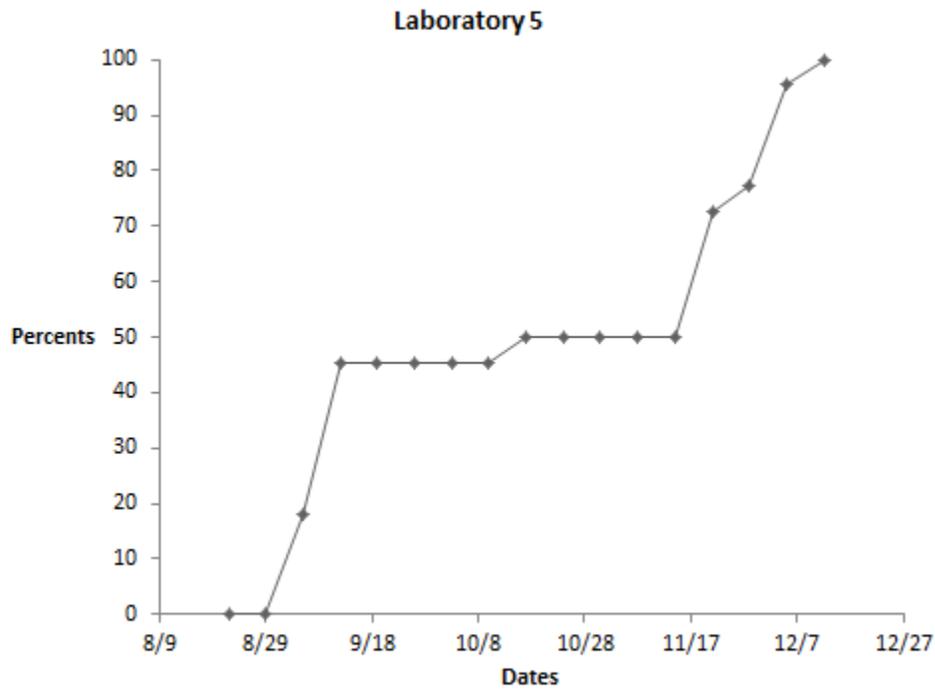
C.



D.



E.



F.

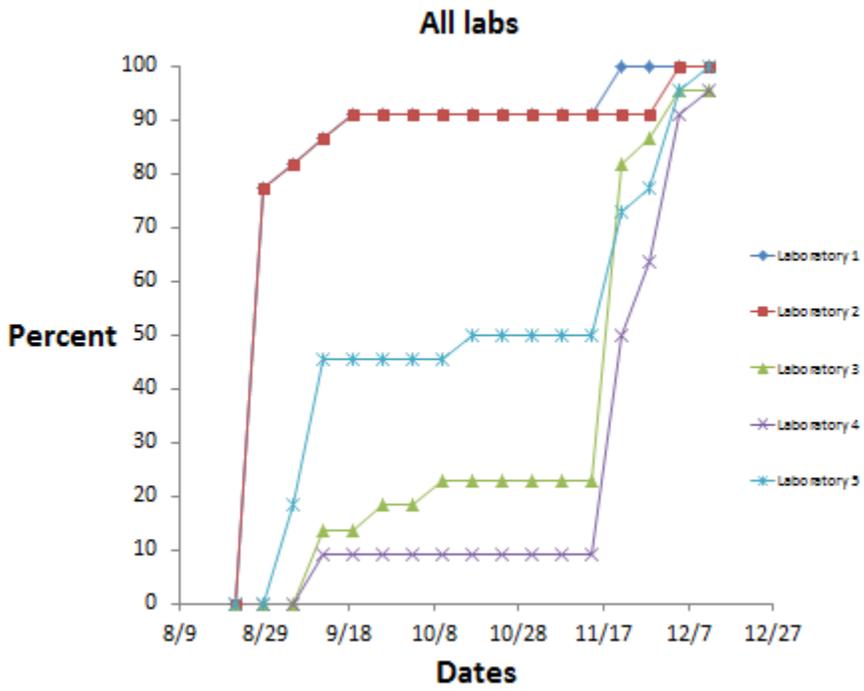


Figure 3. (A-E) Cumulative histograms showing class completion rates for individual laboratories. **(F)** Cumulative histogram showing class completion rates for each of the five laboratories.

Figure 4

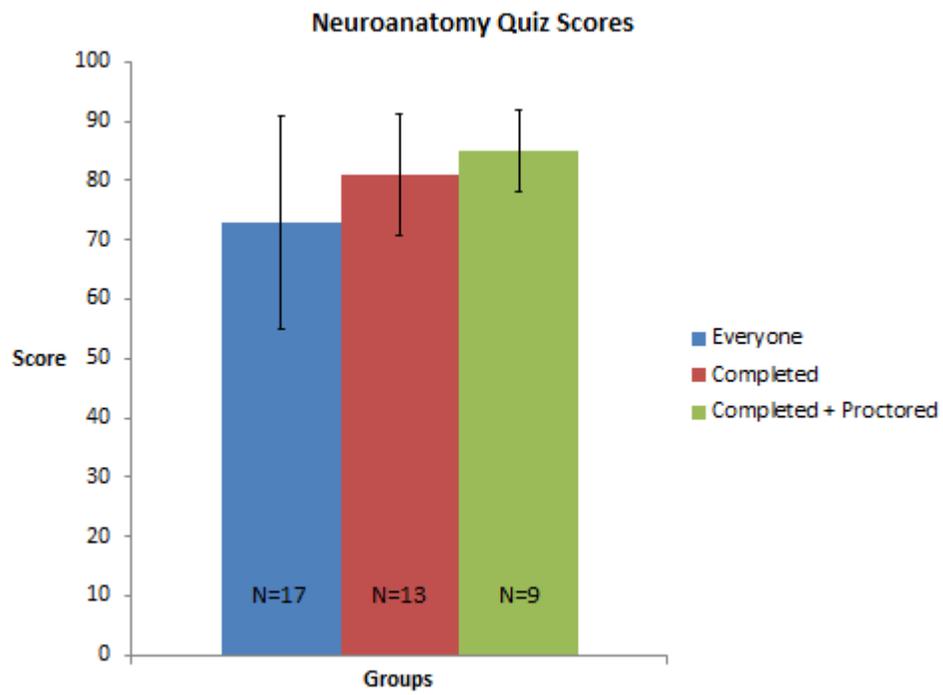


Figure 4. Graph displaying quiz performance for everyone who took the quiz (blue), everyone who had completed the entire curriculum prior to the quiz (red), and everyone who had completed the entire curriculum and proctored at least one of their peer's laboratories prior to the quiz (green).

Figure 5

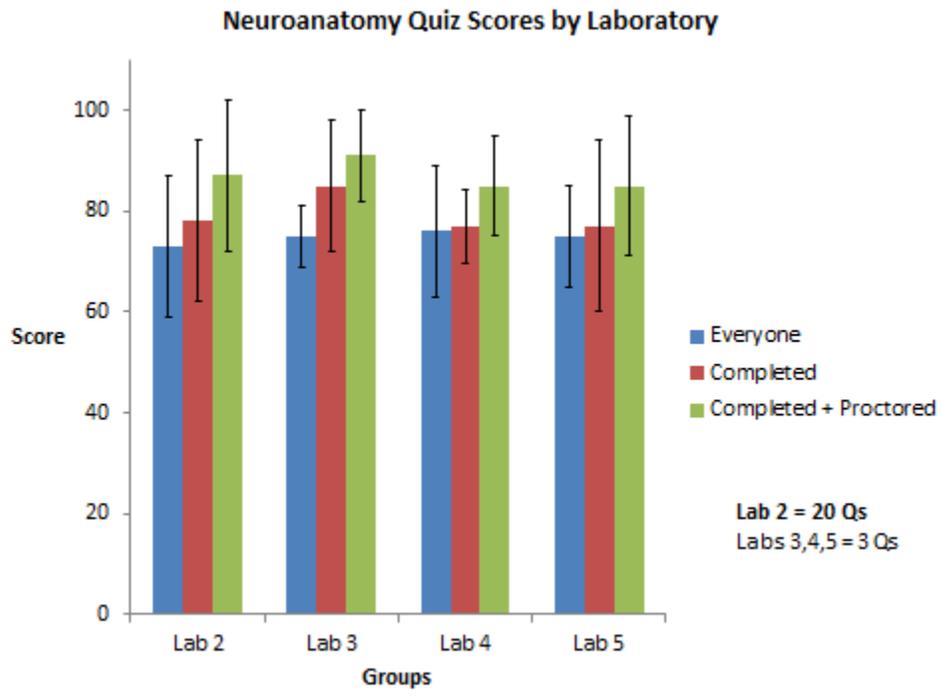


Figure 5. Graph displaying quiz performance on individual laboratories for everyone who took the quiz (blue), everyone who had completed the entire curriculum prior to the quiz (red), and everyone who had completed the entire curriculum and proctored at least one of their peer's laboratories prior to the quiz (green).

Figure 6

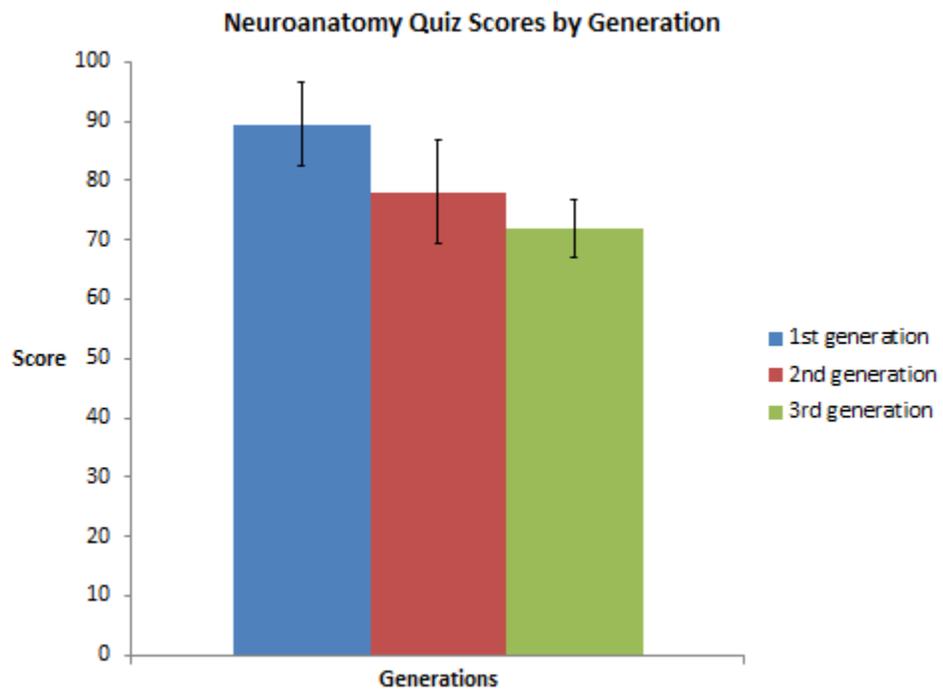


Figure 6. Graph displaying average quiz performance for the 1st, 2nd, and 3rd generations.

Figure 7

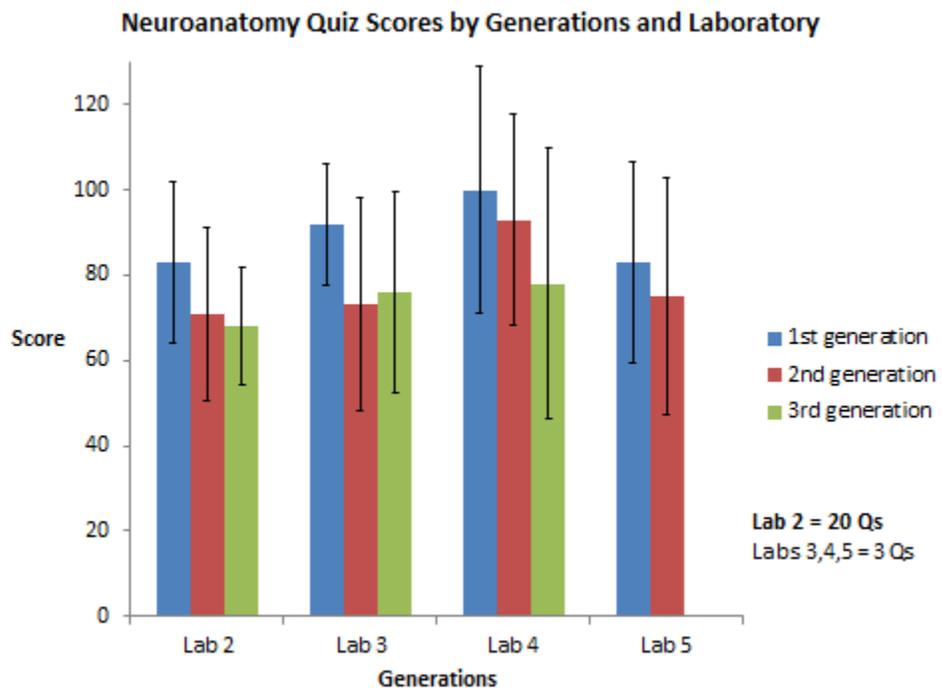


Figure 7. Graph displaying average quiz performance for the 1st, 2nd, and 3rd generations of each laboratory.

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Figure 8

Laboratory 2 Pedigree

(Scores in parenthesis)

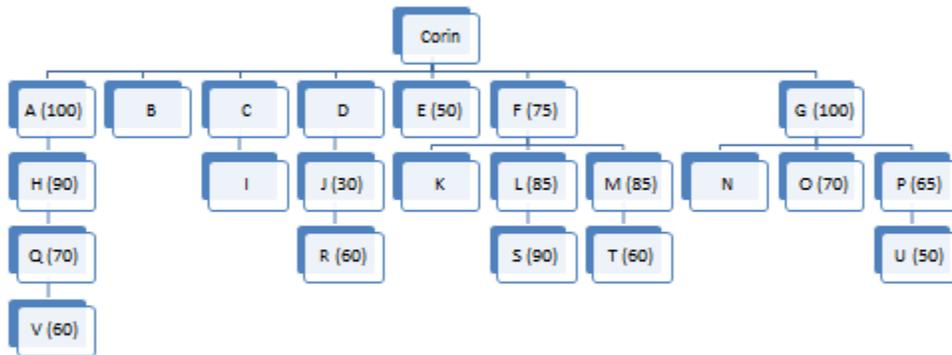


Figure 8. This is a pedigree showing the transfer of neuroanatomical information from the graduate teaching assistant to each of the 4 generations. Student names have been replaced with single letter abbreviations. Laboratory 2 20-item sub-quiz scores are in parenthesis. Students without scores did not take the neuroanatomy quiz.

Figure 9

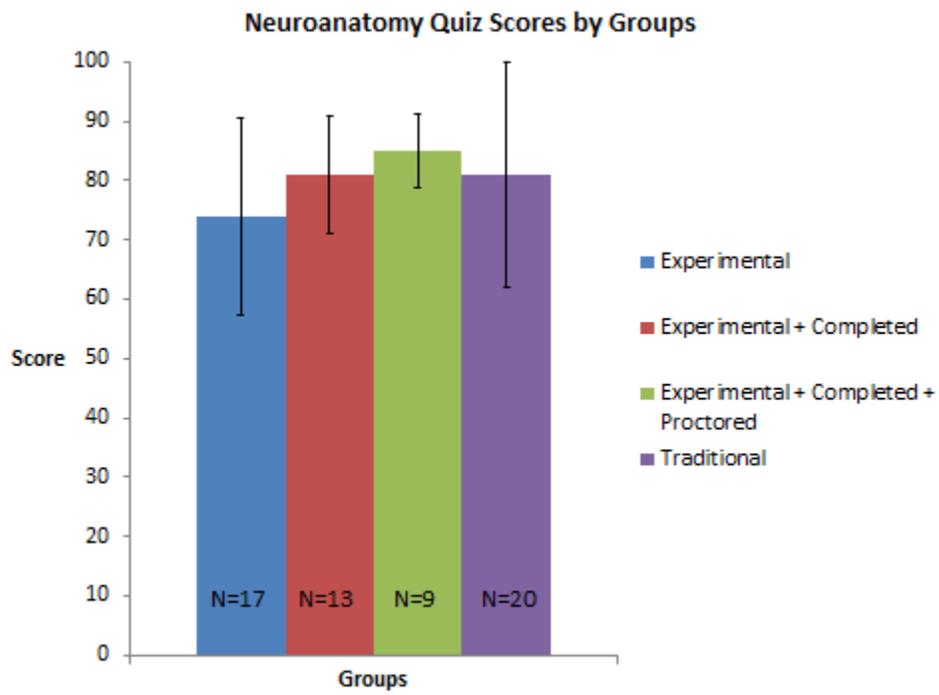


Figure 9. Graph displaying 21-item quiz performance for experimentally (blue, red, and green) and traditionally taught (purple) students.

Figure 10

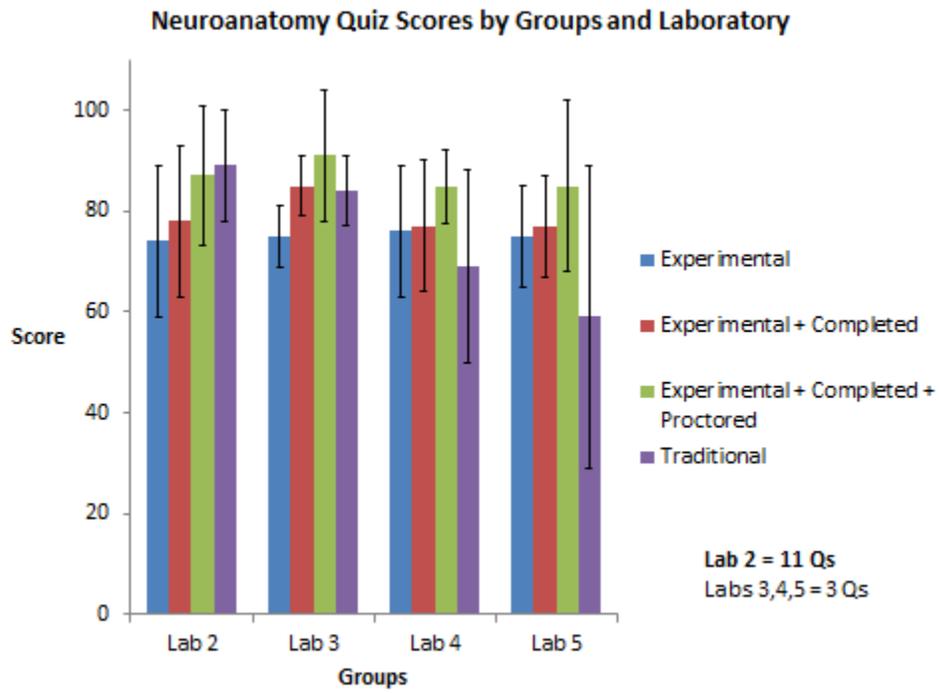


Figure 10. Graph displaying 21-item quiz performance on individual laboratories for experimentally (blue, red, and green) and traditionally taught (purple) students.

Figure 11

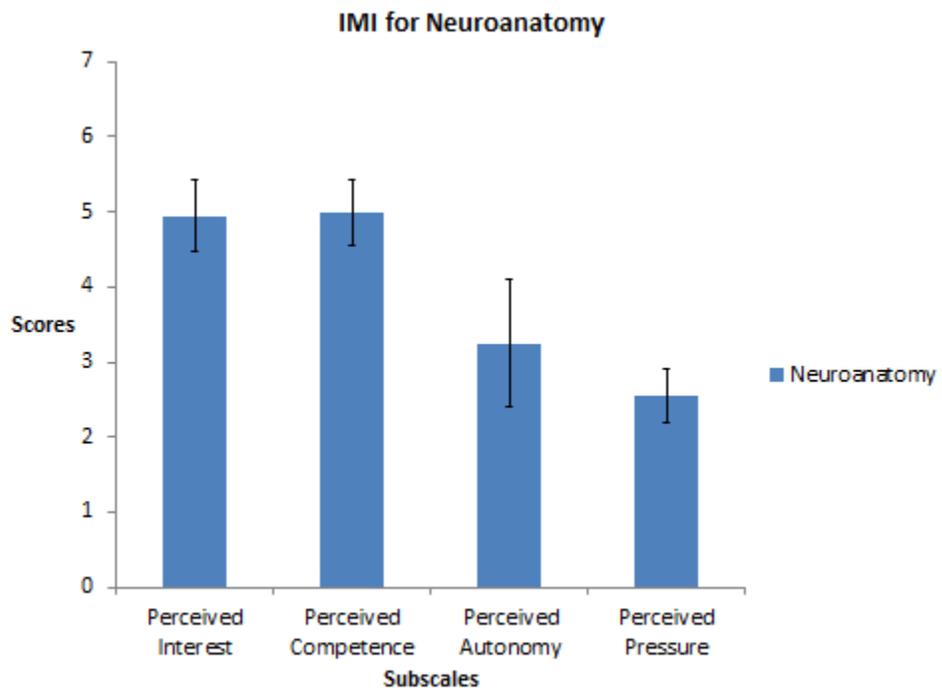


Figure 11. Graph displaying subscale scores on IMI for neuroanatomy laboratories.

IV. Discussion

Anatomy provides scientists with a common vocabulary for discussing the human body, and is, therefore, an important aspect of science education. Literature shows that traditional teaching methods may be enhanced by the employment of mastery-based learning in an autonomy-supportive environment. The present study sought to determine the effects of these teaching strategies on the learning of neuroanatomy in a master's level human neurobiology course. Results show that students learned and reportedly enjoyed learning a large amount of neuroanatomy. Experimentally taught students who had completed the curriculum performed equally as well as traditionally taught students on the 21-item neuroanatomy quiz (both scored an 81%), but scored lower on the 11-item laboratory 2 sub-quiz (78% and 89% respectively). The experimentally taught students also did well on the 30-item neuroanatomy quiz (81%) and 20-item laboratory 2 sub-quiz (78%). Administration of the Intrinsic Motivation Inventory (IMI) revealed that students felt relatively competent (5/7), interested (5/7), and unpressured (5/7) while studying neuroanatomy. However, they did not report high levels of perceived choice (3/7).

Apparent benefits of the new curriculum

The newly designed curriculum made the course load more manageable for students. They were given the freedom to schedule the anatomy labs however they

preferred. All of the designated laboratory periods were optional. This allowed them to focus their attention on other learning responsibilities, such as tests, when appropriate. Figure 12 shows most students began working on the laboratories during the first two weeks of the semester, but mostly waited until the end of the semester to finish them. The intervening time was spent studying for tests and quizzes in both the neuroanatomy and microanatomy courses which were being taken concurrently.

Figure 12

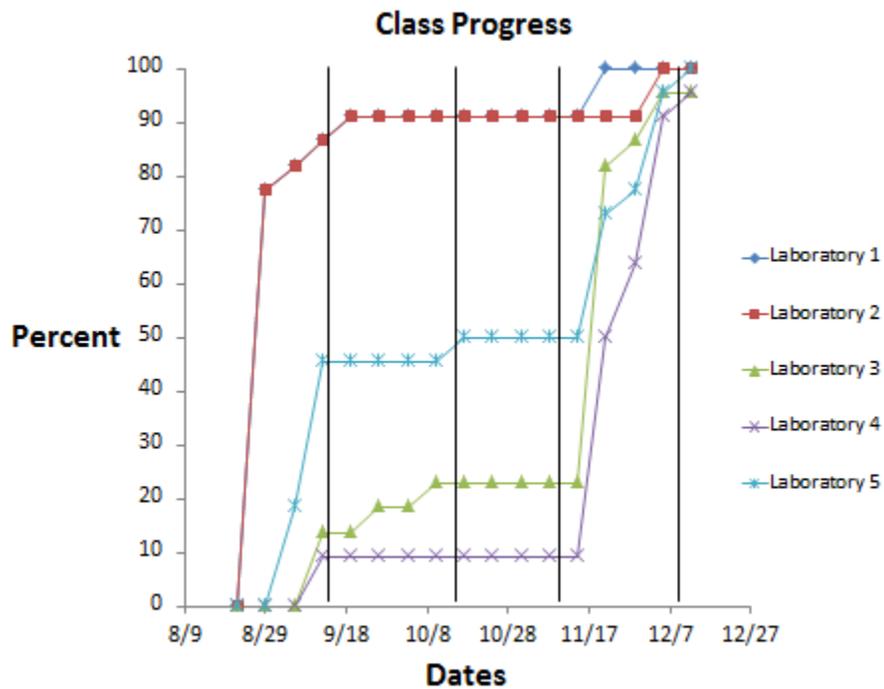


Figure 12. Cumulative histogram showing completion rates for each of the five laboratories. Black lines represent human neurobiology test dates.

The newly designed curriculum gave all of our students a full opportunity to develop competency with neuroanatomy. The majority (21/22) of the students

completed the entire curriculum and received full credit for the neuroanatomy portion of the course. These achievements probably contributed to the students' relatively high levels of self-reported perceptions of competence, which may have led to more intrinsic motivation for the study of neuroanatomy.

The newly designed curriculum made it possible for all of the students to gain valuable teaching experience. Peers proctored the majority (63%) of all laboratories, with 17/22 students proctoring at least once. This probably contributed to the students' self-reported feelings of competence (Perry, Burke, Friel, & Field, 2010), and may be the reason why 1st generation students tended to score higher than 2nd and 3rd generations on the 30-item neuroanatomy quiz (90%, 78%, and 73% respectively). 1st generation students had more opportunities to teach, because they typically completed their laboratories before the majority of their classmates.

The newly designed curriculum appeared to reduce test anxiety. Students knew exactly what they needed to learn, so they were able to determine when they were ready to be assessed. There were no time limits on evaluations (Hill & Eaton, 1977). Every assessment was informative, failing students were able to identify areas they needed to spend more time studying. Students were able to observe their peer's evaluations, which should have further reduced uncertainty about the testing process.

The newly designed curriculum allowed students to spend more time with dissections. Students knew that all of the evaluations were performed with dissections or plastic models. The traditionally taught cohort of students from the previous year

only spent about two hours (1 laboratory session) with prosections. The redesign of the neuroanatomy curriculum to emphasize mastery and autonomy allowed this year's cohort to spend over 12 hours (6 laboratory sessions) with prosections. Students spent even more time looking at prosections if they proctored one of their peer's laboratories later in the semester.

The newly designed curriculum greatly eased the neuroanatomy teaching requirements of the faculty. Once students understood how the curriculum functioned, no lectures were required. Many students were able to successfully complete their evaluations with the GTA, even though all of their learning was the result of either self-directed studying or peer instruction. Students also reported learning neuroanatomy while watching their peers undergo evaluations.

The newly designed curriculum appeared to promote group studying. Starting with the first laboratory period (8/25/14), students were working together to learn neuroanatomy. Some of them had previously attended medical or dental schools and were able to help their comparatively inexperienced classmates. All of our dedicated laboratory periods were highly collaborative; the students were so active that little help was required from instructors.

Students were satisfied with our curriculum. Administration of the IMI showed that they relatively enjoyed the study of neuroanatomy (5/7). In addition, many students reported being glad that neuroanatomy instruction was not delivered through

lectures. Some also expressed confusion that neuroanatomy had not been taught this way before, to them; it was obviously a better way to learn.

Our curriculum promoted long-term retention of neuroanatomical knowledge. The majority (90%) of the students completed laboratory 2 within the first 2 weeks of the semester, over 3 months before taking the quiz; the students were only notified we would be administering the quiz the evening before, giving them no time to review; and they knew they would not be graded on their quiz performance, so they may not have been trying as hard as the traditionally taught students. However, they still scored just as well as the previous year's traditionally taught students who had study guides, knew when the test would be given, and were graded on their performance.

Possible motivational benefits of the newly designed curriculum

Students engage with school for a variety of reasons. Some are primarily concerned with learning and self-improvement, while others are more interested in how their academic performance compares with classmates. This section will discuss some characteristics of these motivational approaches to learning, and conclude with an explanation of the possible motivational benefits of the newly designed curriculum.

Mastery

Mastery oriented students are primarily concerned with their own self-improvement (not with how they compare to others). Therefore, they prefer to engage in difficult tasks which will help them approve their abilities. They take pride in achieving

success after expending large amounts of effort. They persist after experiencing failure, believing that more effort will bring success, which is why they are more likely to achieve high levels of competence (Covington, 1984).

Performance

Performance oriented students are primarily concerned with how their performance compares with their classmates. Some students want to make sure everyone sees how smart they are (performance-approach), while some want to make sure that no one notices how dumb they are (performance-avoidance) (Elliot, 1999).

Performance oriented students are likely to believe that ability is fixed and negatively correlated with effort, meaning: high effort success signals low ability, low effort success signals high ability, high effort failure signals very low ability, and low effort failure does not indicate high or low ability. They are not likely to persist after experiencing failure, especially if they made a large effort, because they do not believe their low ability can be improved (Nicholls, 1984).

Students are more likely to develop a performance orientation to learning in competitive environments due to the numerous intentional social comparisons (Nicholls, 1984). For example, in the anatomy program student grades are posted on the classroom door, awards are given out to the highest scoring student, tests are curved, and students compete for teaching assistantships. As a result, studying becomes a means to an end, to enable one to either win or to avoid losing, leading to significant decreases in intrinsic motivation for learning (Nicholls, 1984).

Performance - Approach

Students primarily concerned with proving their superiority over classmates tend to act in ways that will display their high levels of ability. They tell peers that they put little effort into preparing for tests, even if that is a lie, because they will appear brilliant if they score well and will also avoid looking dumb if they score poorly (Covington, 1984). They will also avoid doing things that are too easy or too hard, because they will not have an opportunity to distinguish themselves from others. For example, they are not likely to answer in-class discussion questions if they believe everyone knows the answer, or they do not know the answer (Nicholls, 1984).

Performance - Avoidance

Students who do not want to prove their inferiority tend to act in ways that will help avoid looking stupid. For example, they do not do anything that is not required (Covington, 1984), because it provides the teacher with fewer opportunities to criticize them. They procrastinate (Beery, 1975), because low effort failures do not provide any information about their level of ability; and they put more effort into challenges that are easy or extremely difficult, avoiding things that are only moderately difficult, because they experience success with easy tasks and almost everyone fails extremely difficult tasks (Nicholls, 1984).

These strategies are self-sabotaging; their employment results in lower levels of achievement (Nicholls, 1984). Repeated failures cause students to believe they possess only low levels of ability, and, because they are likely to believe that ability is fixed, they

enter a state of learned helplessness characterized by feelings of shame and depression (Wortman & Brehm, 1975).

This fear of failure is also the reason many students experience test anxiety, they believe that examinations will expose their stupidity. Some students respond by overstriving, paying slavish attention to detail while over-studying, thus ensuring success (Covington, 1984). However, their successes invoke more anxiety; they do not attribute their success to high levels of ability, but to external factors over which they have no control. They believe that the next examination will expose how stupid they really are. This strategy also makes them vulnerable to attributions of very low ability because there is still a possibility of failure (Covington, 1984).

Possible Motivational Outcomes

We believe our curriculum fostered a mastery orientation, while inhibiting the development of a performance orientation, for learning neuroanatomy. Students were not compared with each other, everyone who completed a laboratory received the same level of credit, there were no competitions or curved grades. Students were allowed to self-pace, this allowed them to focus on mastering the material and improving themselves. Students were given multiple opportunities to achieve mastery; anxiety should have been greatly diminished because they were not punished for failures and failures were not shared with classmates. In addition, almost all students in the experimentally taught cohort achieved the same level of mastery by the end of the semester.

Reconciliation of mastery achievement with imperfect quiz performance

There were no perfect scores on any version of the neuroanatomy quiz. Experimentally taught students who had completed the curriculum averaged an 81% on the 30-item quiz and a 78% on the 20-item laboratory 2 sub-quiz. There could be several factors which had an effect on the quiz performance of the experimentally taught students.

Quiz performance may have been better if we had required students to memorize names of structures, because test performance relies mostly on the ability to remember, not necessarily the ability to understand. The goal of our curriculum was to help students develop an understanding of and become familiar with the process of learning neuroanatomy, not to memorize long lists of structures. Biology students are currently spending large amounts of time memorizing relatively few anatomical structures. I believe their time would be better spent learning how to use available resources (atlases, prosections, cadavers, etc...) to identify relevant structures for themselves. This would enable them to continue learning even after leaving our programs.

Not everyone had completed the entire curriculum prior to administration of the quiz. As a result, they may have missed many questions of which they knew the answer. Repeated experiences of failure, i.e. not recognizing question material, may have led some students into a state of learned helplessness. Causing them to put less effort into questions they should have been able to answer correctly. Future quizzes should not

group together questions from particular portions of the study material or questions that are extremely difficult. It may also be beneficial to begin future quizzes with relatively easy questions.

We discovered no evidence of cheating. The newly designed curriculum did not offer many reasons to cheat. Students were not punished for failures, there were no deadlines, they were told exactly what they needed to know, and they were able to observe the evaluations of their peers.

Students lacking interest in neuroanatomy probably forgot much of what they learned after they received credit. Coercing students to study has not been shown to result in as much deep learning as providing them with autonomy. Literature shows students are more likely to adopt our views, and study difficult material with the goal of self-improvement, if they are helped to understand the value of everything being taught. This can be accomplished by giving them choices, acknowledging the material may be boring or uninteresting, and by explaining the relevance of what is being taught (Deci, Vallerand, Pelletier, & Ryan, 1991).

Students may have perceived the quiz as anxiety provoking. It has been shown that students with high test anxiety usually perform poorly on educational tests; regardless of how much knowledge they possess (Hill, 1984). This makes our quiz results less useful for determining the efficacy of our neuroanatomy curriculum.

Limitations of our study

This was a pilot study and as such had several limitations. We had a small sample size. There is no comparison for the results we obtained from the IMI; no one has ever administered it to students in a graduate level human neuroanatomy laboratory. The testing conditions between the experimentally and traditionally taught cohorts varied greatly: questions were given in different orders and at different times during the semester between groups, and were only graded for the traditionally taught cohort.

Refinements

There are a number of refinements that should be made to any future studies involving self-paced anatomy learning. The IMI should be administered before and after the course, this would make it possible to identify changes in intrinsic motivation. Students should include their name when filling out the IMI; this would make it possible to identify correlations between motivation and achievement. A questionnaire designed to identify motivational approaches to learning should be administered before and after the course, this would make it possible to look for correlations between motivation and performance and identify any changes in our students' approaches to learning. The number of failed attempts at each laboratory should be recorded; these failures may have strong motivational impacts that effect future learning positively or negatively. Students should be provided with a recommended schedule for laboratory completion, this additional structure would be beneficial for students with little or no previous exposure to self-directed learning.

Future of autonomy-supportive and mastery-based anatomy instruction

Students learned large amounts of neuroanatomy during their regular class periods; they did not need to study outside of class. If the entire class were structured according to our curriculum, would they be able to learn all of the material without studying outside of regular class periods? If so, students may be able to complete all of the core courses in the graduate anatomy program in one semester (~34 hours per week, ~7 hours per day). This would give them more time to gain teaching and research experience before graduating.

Autonomy-supportive and mastery-based instruction should be employed in larger classes. I believe that, with this structure, larger class sizes would actually improve our students' educational experience. It has been shown that peer instruction results in higher levels of performance and confidence for both the tutor and the tutee (Perry, Burke, Friel, & Field, 2010). 77% of the students in our class served as peer evaluators, but I believe that all of our students engaged in some level of peer tutoring. During most dedicated laboratory sessions, the professors and graduate teaching assistant did little more than observe the students teaching one another, sometimes for as long as two hours with no breaks. As a result, many students were able to successfully complete their evaluations with the graduate teaching assistant, even though all of their learning was the result of self-directed studying or peer instruction.

I believe that this type of curriculum would provide numerous benefits to undergraduate STEM courses. It has been shown that autonomy-supportive teachers

can influence future career decisions of their students (Williams, Saizow, Ross, & Deci, 1997; Williams, Wiener, Markakis, Reeve, & Deci, 1994). Therefore, I believe the application of an autonomy-supportive curriculum will result in both a decreased attrition rate for STEM majors, and a larger number of graduates intending to pursue STEM careers. Employment of a mastery-based curriculum should also reduce parent complaints in undergraduate education. If we give students a full opportunity to learn, parents will be unable to blame us for their child's poor performance. It should reduce the teaching load for professors. The number of lectures would be greatly reduced. Students would learn to either find their own answers or work with their peers. Professors would not have to field complaints about course unfairness.

Appendix A

Neuroanatomy Laboratory

Manual

Will only be seen on picture

May be seen on prosection

Found on plastic sections or models

Found on prosections

Resources: Powerpoint slides on Pilot, Netter's atlas of Neuroscience on Clinical Key

Lab 1 – Directional Terms (see “Gray’s Basic Anatomy” – Clinical Key)

1. Demonstrate the anatomical position
2. Explain the uses of the following anatomical terms

Anterior/Posterior

Dorsal/Ventral

Rostral/Caudal

Proximal/Distal

Medial/Lateral

Horizontal plane (transverse,
axial)

Coronal plane (frontal)

Sagittal (mid-sagittal,
parasagittal)

Superficial/Deep

Superior/Inferior

Lab 2

1. Identify the following anatomical landmarks on prosections
2. Identify the specific locations of the functional areas and describe their functions

5 Lobes of Cerebrum

Frontal lobe
Parietal lobe
Temporal lobe
Occipital lobe
Limbic lobe

Subdivisions of Frontal lobe

Precentral gyrus and sulcus
Superior, middle, and inferior frontal gyrus
Anterior paracentral lobule
Superior and inferior frontal sulci

Subdivisions of Parietal lobe

Postcentral gyrus and sulcus
Intraparietal sulcus
Supramarginal gyrus
Angular gyrus
Superior parietal lobule
Precuneus
Posterior paracentral lobule

Subdivisions of Occipital lobe

Cuneus
Lateral occipital gyri
Lingual gyrus
Occipitotemporal gyrus

Subdivisions of Temporal lobe

Superior, middle, and inferior temporal gyri
Superior and inferior temporal sulci
Occipitotemporal sulcus

Limbic lobe

Cingulate gyrus
Parahippocampal gyrus
Uncus

Fissures and Sulci

Longitudinal fissure
Central sulcus
Lateral sulcus
Preoccipital notch
Parietooccipital sulcus
Cingulate sulcus
Collateral sulcus

Insula cortex

Parietal, Temporal, and Frontal operculae

Meninges

Dura mater
Arachnoid mater
Subarachnoid space
Pia mater

Functional Areas

Broca's
Wernicke's
Primary motor cortex
Premotor area
Prefrontal cortex
Primary auditory cortex
Auditory association area
Primary visual cortex
Visual association area
Primary somatosensory cortex
Somatosensory association area

Lab 3

1. Identify the following anatomical landmarks, draw and label tracts
2. Describe the functions of the pathways, spinal cord, brainstem, and each of the cranial nerves

Spinal Cord

Ventral median fissure
Dorsal median sulcus
Dorsolateral sulcus
Ventrolateral sulcus
Central canal
Ventral horn
Dorsal horn
Lateral horn
Ventral funiculus
Lateral funiculus
Dorsal funiculus
Dorsal root ganglion
Dorsal root
Ventral root
Spinal nerve

Brainstem

Midbrain
Pons
Medulla
Tectum
Tegmentum

Descending Pathways

cerebral peduncle
pyramids
red nucleus
medial longitudinal fasciculus (MLF)

Sensory pathways

fasciculus gracilis
fasciculus cuneatus
anterior white commissure
Zone of Lissauer
spinothalamic tract
dorsal spinocerebellar tract
nucleus gracilis
nucleus cuneatus
lateral cuneate nucleus
internal arcuate fibers
medial lemniscus
posterior limb of internal capsule
spinal trigeminal tract
spinal trigeminal nucleus
trigeminal ganglion
optic nerve
optic chiasm
optic tract
superior colliculus
lateral geniculate nucleus
lingual gyrus
cuneus gyrus
calcarine sulcus

Cranial Nerves

olfactory nerve (I)
optic nerve (II)
oculomotor nerve (III)
trochlear nerve (IV)
trigeminal nerve (V)
abducens nerve (VI)
facial nerve (VII)
vestibulocochlear (VIII)
glossopharyngeal nerve (IX)
vagus nerve (X)
spinal accessory (XI)
hypoglossal nerve (XII)

Lab 4

1. Identify the following anatomical landmarks, describe location
2. Explain the functions of the thalamus, cerebellum, basal ganglia, hypothalamus, and limbic system

Cerebellum

Vermis

Lateral hemispheres

primary fissure

anterior lobe

posterior lobe

flocculonodular lobe

superior cerebellar peduncle

middle cerebellar peduncle

inferior cerebellar peduncle

dentate nucleus of cerebellum

Thalamus

interthalamic adhesion

anterior limb of internal capsule

genu of internal capsule

posterior limb of internal capsule

lateral geniculate nucleus

medial geniculate nucleus

dorsomedial nucleus

pulvinar nucleus

Hypothalamus and limbic system

mammillary body

median eminence

hypothalamus

fornix

amygdala

hippocampus

Dentate gyrus

cingulate gyrus

Areas important in addiction

ventral tegmental area

nucleus accumbens

ventral pallidum

Basal Ganglia

Corpus Striatum

caudate nucleus

putamen

Pallidum

globus pallidus external segment

globus pallidus internal segment

substantia nigra pars reticulata

Other Basal Ganglia Structures

substantia nigra pars compacta

ansa lenticularis

lenticular fasciculus

thalamic fasciculus

subthalamic nucleus

Other structures

Corpus callosum

Anterior commissure

Pineal gland

Superior colliculus

Inferior colliculus

Lab 5

1. Identify the following blood vessels and their perfusion zones, Explain locations
2. Explain the main functional difference between arteries and veins
3. Identify the vessels that make up the Circle of Willis
4. Explain the importance of anastomotic connections
 - a. Identify the main anastomotic vessels of the spinal cord
5. Explain the concept of watershed zones in the brain
6. Explain the function of the arachnoid villi (granulations)

Arteries

Anterior cerebral artery

Anterior communicating artery

Middle cerebral artery

Posterior cerebral artery

Posterior communicating artery

Basilar artery

Vertebral arteries

Internal carotid arteries

Superior cerebellar arteries

Inferior anterior cerebellar arteries

Inferior posterior cerebellar arteries

Anterior spinal artery

Posterior spinal artery

Arterial vasocorona

Pontine arteries

Lenticulostriate arteries

Veins

Superior sagittal sinus

Straight sinus

Sigmoid sinus

Internal jugular veins

Arachnoid villi (granulations)

Bibliography

- Amabile, T. M., Dejong, W., & Lepper, M. R. (1976). Effects of Externally Imposed Deadlines on Subsequent Intrinsic Motivation. *Journal of Personality and Social Psychology*, 92-98.
- Ames, C. (1984). *Competitive, cooperative, and individualistic goal structures: a cognitive-motivational analysis* (Vol. Research on motivation in education). (R. E. Ames, & C. Ames, Eds.) San Diego, California: Academic Press, Inc.
- Amorose, A. J., & Anderson-Butcher, D. (2007). Autonomy-supportive coaching and self-determined motivation in high school and college athletes: A test of self-determination theory. *Psychology of Sport and Exercise*, 654-670.
- Beery, R. G. (1975). Fear of failure in the student experience. *Personnel and Guidance Journal*, 190-203.
- Benita, M., Roth, G., & Deci, E. L. (2013). When Are Mastery Goals More Adaptive? It Depends On Experiences of Autonomy Support and Autonomy. *Journal of Educational Psychology*, Advance online publication. doi: 10.1037/a0034007.
- Bloom, B. S. (1971). *Learning for Mastery*. New-York: McGraw-Hill.
- Bloom, B. S. (1984). The 2 Sigma Problem: The Search for Methods of Group Instruction as Effective as One-to-One Tutoring. *Educational Researcher*, 4-16.
- Covington, M. V. (1984). *The motive for self-worth* (Vol. Research on motivation in education). (C. Ames, & R. E. Ames, Eds.) San Diego, California: Academic Press, Inc.
- Deci, E. L., Betley, G., Kahle, J., Abrams, L., & Porac, J. (1981). When Trying To Win: Competition and Intrinsic Motivation. *Personality and Social Psychology Bulletin*, 79-83.

- Deci, E. L., Koestner, R., & Ryan, R. M. (1999). A Meta-Analytic Review of Experiments Examining the Effects of Extrinsic Rewards on Intrinsic Motivation. *Psychological Bulletin*, 627-668.
- Deci, E. L., Vallerand, R. J., Pelletier, L. G., & Ryan, R. M. (1991). Motivation and Education: The Self-Determination Perspective. *Educational Psychologist*, 325-346.
- Drew, C. (2011, November 4). *Why Science Majors Change Their Minds (It's Just So Darn Hard)*. Retrieved from The New York Times: http://www.nytimes.com/2011/11/06/education/edlife/why-science-majors-change-their-mind-its-just-so-darn-hard.html?pagewanted=all&_r=0
- Elliot, A. J. (1999). Approach and Avoidance Motivation and Achievement Goals. *Educational Psychologist*, 169-189.
- Flink, C., Boggiano, A. K., & Barrett, M. (1990). Controlling Teaching Strategies: Undermining Children's Self-Determination and Performance. *Journal of Personality and Social Psychology*, 916-924.
- Fullagar, C. J., & Mills, M. J. (2008). Motivation and Flow: Toward an Understanding of the Dynamics of the Relation in Architecture Students. *The Journal of Psychology*, 533-553.
- Grolnick, W. S., & Ryan, R. M. (1987). Autonomy in Children's Learning: An Experimental and Individual Difference Investigation. *Journal of Personality and Social Psychology*, 890-898.
- Hill, K. T. (1984). *Debilitating motivation and testing: a major educational problem-possible solutions and policy applications* (Vol. Research on motivation in education). (R. E. Ames, & C. Ames, Eds.) San Diego, California: Academic Press, Inc.
- Hill, K. T., & Eaton, W. O. (1977). The interaction of test anxiety and success-failure experiences in determining children's arithmetic performance. *Developmental Psychology*, 205-211.
- Kinzie, M. B., & Sullivan, H. J. (1989). Continuing Motivation, Learner Control, and CAI. *Educational Technology Research and Development*, 5-14.

- Kinzie, M. B., Sullivan, H. J., & Berdel, R. L. (1988). Learner Control and Achievement in Science Computer-Assisted Instruction. *Journal of Educational Psychology*, 299-303.
- LeBlanc, L. B. (1992). The Fast Track: A Self-Paced Approach to Learning French. *College Teaching*, 142-145.
- Liao, S. S. (1978). Learner Directed Instruction: Additional Evidences. *The Accounting Review*, 155-161.
- Nicholls, J. G. (1984). *Conceptions of ability* (Vol. Research on motivation in education). (C. Ames, & R. E. Ames, Eds.) San Diego, California: Academic Press, Inc.
- O'Donnell, S. L., Chang, K. B., & Miller, K. S. (n.d.). RELATIONS AMONG AUTONOMY, ATTRIBUTION STYLE, AND HAPPINESS IN COLLEGE STUDENTS. *College Student Journal*, 228-234.
- Patall, E. A., Dent, A. L., Oyer, M., & Wynn, S. R. (2013). Student autonomy and course value: The unique and cumulative roles of various teacher practices. *Motivation & Emotion*, 14-32.
- Perry, M. E., Burke, J. M., Friel, L., & Field, M. (2010). Can training in musculoskeletal examination skills be effectively delivered by undergraduate students as part of the standard curriculum? *Rheumatology*, 1756-1761.
- Reeve, J., & Tseng, C.-M. (2011). Cortisol reactivity to a teacher's motivating style: the biology of being controlled versus supporting autonomy. *Motivation and Emotion*, 63-74.
- Ryan, R. M., & Deci, E. L. (2000). Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being. *American Psychologist*, 68-78.
- Savard, A., Joussemet, M., Pelletier, J. E., & Mageau, G. A. (2013). The benefits of autonomy support for adolescents with severe emotional and behavioral problems. *Motivation and Emotion*, 688-700.
- Shim, S., & Ryan, A. (2005). Changes in Self-Efficacy, Challenge Avoidance, and Intrinsic Value in Response to Grades: The Role of Achievement Goals. *The Journal of Experimental Education*, 333-349.
- Standage, M., Duda, J. L., & Ntoumanis, N. (2006). Students' Motivational Processes and Their Relationship to Teacher Ratings in School Physical Education: A Self-

Determination Theory Approach. *Research Quarterly for Exercise and Sport*, 100-110.

Vansteenkiste, M., Simmons, J., Lens, W., Deci, E. L., & Sheldon, K. M. (2004). Motivating Learning, Performance, and Persistence: The Synergistic Effects of Intrinsic Goal Contents and Autonomy-Supportive Contexts. *Journal of Personality and Social Psychology*, 246-260.

Vazou-Ekkekakis, S., & Ekkekakis, P. (2009). AFFECTIVE CONSEQUENCES OF IMPOSING THE INTENSITY OF PHYSICAL ACTIVITY: DOES THE LOSS OF PERCEIVED AUTONOMY MATTER? *Hellenic Journal of Psychology*, 125-144.

Williams, G. C., & Deci, E. L. (1996). Internalization of Biopsychosocial Values by Medical Students: A Test of Self-Determination Theory. *Journal of Personality and Social Psychology*, 767-779.

Williams, G. C., Saizow, R., Ross, L., & Deci, E. L. (1997). Motivation underlying career choice for internal medicine and surgery. *Social Science and Medicine*, 1705-1713.

Williams, G. C., Wiener, M. W., Markakis, K. M., Reeve, J., & Deci, E. L. (1994). Medical student motivation for internal medicine. *Journal of General Internal Medicine*, 327-333.

Wortman, C. B., & Brehm, J. W. (1975). Responses to uncontrollable outcomes: An integration of reactance theory and the learned helplessness model. In L. E. Berkowitz, *Advances in experimental social psychology*. New York: Academic Press.