No Bones About It: Using Coloring Assignments to Improve Anatomy Instruction

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Abstract
As a result of completing weekly coloring assignments, students enrolled in our Anatomy & Physiology I course significantly outperformed their previous-semester counterparts on the course’s midterm final laboratory practical exams. Qualitative feedback from students suggests that students found the coloring assignments created a positive and relaxing atmosphere for the studying of anatomy. Overall coloring assignments increased student performance in this course.

Key Words: anatomy; coloring; community college.

Introduction
As anatomy supports the development of many clinical skills, healthcare providers require a thorough understanding of the field (Dangerfield et al., 2000). Despite the critical nature of anatomy, it has been argued that students who complete modern anatomy courses possess less knowledge than those in prior years (Bergman et al., 2011). Students enrolled in introductory anatomy often struggle with the volume of complex information that, when coupled with poor study skills and background knowledge, can hinder learning (Schutte, 2016). Instructors of anatomy across the globe will likely be familiar with coloring books (see Hansen, 2018; Kapit & Elson, 2014), which claim to improve students’ educational experiences while increasing content knowledge. In light of the difficulties students experience in learning anatomy, it is not surprising that such study aids have flooded the market.

Public school educators see the benefits of integrating the arts in science education (Guyotte et al., 2014), and there is a long tradition of using art to teach anatomy at the collegiate level (Bell & Evans, 2014). For example, the creation of anatomy-based comic strips has been found to increase content retention (Park et al., 2011). Furthermore, painting anatomical structures on body surfaces is becoming an increasingly common method of engaging university students with course content (Finn et al., 2011; Finn & Mclachlan, 2010), and multiple studies document the benefits of requiring students to draw anatomical regions (Alsaid & Bertrand, 2015) and histological samples (Cogdell et al., 2015). Anatomy textbooks, atlases, and online learning modules have long made use of color coding to help students develop an understanding of the spatial relationships between structures (O’Byrne et al., 2008). As Gravenhorst (2007) found that formal integration of nontraditional activities and assessments positively impacts students’ knowledge of anatomy, we hypothesized improved performance for our students on lab assessments. In light of this, we elected to incorporate weekly coloring assignments in a first-semester anatomy course at a rural community college in North Carolina.

In Anatomy & Physiology I, we discuss such topics as the integumentary, muscular, skeletal, and nervous systems, in addition to cellular physiology. Unfortunately, multiple factors may hinder student performance in anatomy and physiology. For example, students may feel overwhelmed by the sheer number of muscles and bones assigned and often see this task as little more than an exercise in memorization (McCarroll et al., 2009). Traditionally, anatomy courses have a high percentage of students who receive grades of D, W, or F (Lieu et al., 2018), and by incorporating coloring assignments, the authors hope to improve both student success and learning.

Method
During the spring and fall 2017 terms, one of the authors taught multiple sections of Anatomy & Physiology I at a community college in rural North Carolina. The exam formats and curriculum remained consistent other than the coloring activities. In both terms, students received a list of bones and muscles they would be required to identify from memory without a word bank. Students in spring (n = 68) and fall (n = 73) entered the course with similar levels of prerequisite knowledge as measured by a pretest on the first day of class.

Each student enrolled in Anatomy & Physiology I during the fall 2017 term was required to obtain their own copy of a specified anatomy coloring book. At the beginning of each week, the instructor identified pages that most closely aligned with that week’s lecture and laboratory content (Table 1). Students would then work on
the assigned coloring assignments throughout the week and upload photos or scans of their work to the corresponding assignment link in the Learning Management System.

Once the due date for a coloring assignment passed, the instructor assessed each submission using the coloring assignment grading rubric (Table 2). In addition to a numerical score, students received holistic qualitative feedback regarding their submission. For example, students were made aware if their submission looked hurried or colors did not observe figure boundaries, as this suggests a lack of content engagement and reflection (Carsley & Heath, 2020).

### Results

Students who completed the required routine coloring assignments in fall 2017 outperformed their spring 2017 noncoloring counterparts on bone identification exams (Figure 1) and muscle identification exams (Figure 2). The difference in exam scores between the groups were found to be statistically significant when analyzed using an independent t-test (p < 0.05).

At the end of fall 2017, students anonymously replied to the questions “What did you like about the coloring assignments?” and “What would you recommend changing about the coloring assignments?” Using a thematic coding technique (Miles et al., 2014), the authors identified six central themes from the student responses (Table 3). We created categories for the themes using a subsumption process by reading responses until a relevant concept was encountered and either subsuming this under an established category or establishing a new category. We continued this process until the point of saturation, when no more additional concepts were found. Table 4 contains representative examples of positive and negative student comments related to the coloring assignments. An overwhelming 67% of students described the coloring assignments as helping facilitate their learning of anatomy. The instructor selected this particular coloring book due to its specific instructions. For example, each drawing has multiple structures indicated and includes detailed instructions on which color should be used for a given structure. Not surprisingly, 38% of students found these instructions overly complicated or confusing, a fact they felt may have hindered their learning, and 21% of students directly related their success on the bone and muscle exams to diligently working...
Table 2. Coloring assignment grading rubric.

|                      | Advanced                                      | Proficient                                    | Developing                              | Not Evident                             |
|----------------------|-----------------------------------------------|----------------------------------------------|-----------------------------------------|-----------------------------------------|
| **Accuracy**         | All labeled structures are colored according to instructions. (6 pts.) | Most labeled structures are colored according to instructions; 1–2 structures incorrectly colored. (4 pts.) | Few labeled structures colored according to instructions, more than 3 structures incorrectly colored. (2.5 pts.) | Assignment not submitted. (0 pts.)     |
| **Aesthetics**       | Clear evidence of time spent on coloring assignments, no stray marks, all coloring occurs within lines. May include evidence of texture and shading. (6 pts.) | Clear evidence of time spent on coloring assignments, 1–2 stray marks, most coloring occurs within lines. May includes evidence of texture and shading. (4 pts.) | Assignment appears rushed. Stray marks are apparent and much coloring does not stay within lines. (2.5 pts.) | Assignment not submitted. (0 pts.)     |
| **Total:**           |                                               |                                              |                                         |                                         |
| **Max score:**       | 12 points, per page assigned                  |                                              |                                         |                                         |

Table 3. Code development and frequency.

| Code Description                              | Percent of Responses |
|-----------------------------------------------|----------------------|
| Found the coloring assignments helpful       | 68%                  |
| Fun, enjoyable, and/or relaxing               | 40%                  |
| Issues with specific book instructions        | 38%                  |
| Took too much time                            | 31%                  |
| Direct correlation to muscle and bone success | 21%                  |
| Did not see any benefit                       | 7%                   |

Table 4. Selected representative qualitative excerpts.

| Positive                                                                 | Negative                                                                 |
|-------------------------------------------------------------------------|--------------------------------------------------------------------------|
| "I learning as I went along with the coloring assignments. The coloring pages went well with the topics we went over in class." | "It took a lot of time to color because the instructions were so specific." |
| "The coloring assignments were very helpful. The assignments gave a lot of information, helped me study and visualize the structures." | "Focusing on the anatomy stuff was hard because I was focused on getting it done in time." |
| "The coloring exercises helped you to visualize and place where a certain body part was." | "I enjoyed the coloring because it was therapeutic and relaxing, but I was learning at the same time." |
through the coloring assignments. Interestingly, 24% of students reported the coloring assignments to be relaxing and stress-relieving. Yet, 31% of respondents described the coloring activities as requiring too much time despite these benefits.

**Conclusion**

By integrating routine coloring assigning in Anatomy & Physiology I, we observed statistically significant improvement on student exam scores. We hypothesize that this benefit is due to multiple factors. The first is continual routine exposure to course content. Individuals who engage with a topic regularly have been more likely to commit the information to memory (Horst et al., 2011). Science anxiety has been well documented at the collegiate level (Mallow, 2006), and as such it may serve as a barrier to many undergraduates. Recently, Eaton and Tieber (2017) found that when undergraduates were provided with opportunities to color, they reported increased mood and perseverance as well as decreased anxiety. Both free-choice and directed coloring has been found to improve the emotional state of undergraduates (Ashlock et al., 2018), an important consideration as our anatomy students were provided with detailed instructions. Our findings suggest that providing artistic avenues for students to engage with anatomy may reduce some science anxiety, therefore improving student performance.

Finally, coloring may simulate neural connections and foster muscle memory, resulting in increased content retention (Dempsey & Betz, 2001). The writing of notes by hand positively impacts information processing (Manzi et al., 2017), a process which may be mirrored in thoughtful coloring.

As these findings suggest emotional and cognitive benefits of incorporating routine, detailed coloring assignments in anatomy courses, additional exploration to identify its underlying mechanism is warranted. Furthermore, the authors acknowledge the limited sample size and potential for bias in action research (Johnson & Christensen, 2017); therefore, additional inquiry in this area is recommended.

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