ARTICLE
Snack Cake 'Dissection': A Flipped Classroom Exercise to Engage Undergraduates With Basic Neuroanatomy

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This report describes a brief classroom activity for introducing basic neuroanatomical terminology and concepts to undergraduates in a survey-level course. Prior to completing the activity, students watched a short online lecture discussing the relevant material. During class, students worked in groups to 'dissect' snack cakes using the information they learned in the video and then reported and shared their 'results' using anatomical terminology. Quantitative feedback suggests that students found that the exercise was useful practice, that it helped increase their confidence in their ability to learn neuroanatomy, and that it helped increase their interest in the material generally. Data from an online anatomy quiz further supports the exercise's efficacy. Overall, the data suggest that this exercise may be a worthwhile addition to courses that introduce neuroanatomy to undergraduates.

Key words: teaching neuroanatomy, introduction to neuroscience, undergraduates

Although critically important for the undergraduate neuroscience curriculum (Wiertelak and Ramirez, 2008), students often find neuroanatomy to be an intimidating topic. This is troubling, as aspects of the "neurophobia" (Jozefowicz, 1994) that develops in some undergraduates (Fantaneanu et al., 2014) may persist into their graduate training and professional careers (Flanagan et al., 2007; Ridsdale et al., 2007; Zinchuk et al., 2010; McGee et al., 2014). As such, educators have created a number of pedagogical techniques to enhance student interest in neuroanatomy, including the use of computerized materials (Estes, 2007; Gould et al., 2008), employing equivalence-based instruction (Pytte and Fienup, 2012), using clinical case-studies (Sheldon, 2000; Kennedy, 2013), and by exploring synergies between art and anatomy (Watson, 2013). Still, it would be desirable to develop other techniques to increase student engagement with this topic.

Some barriers to learning neuroanatomy may be related to students' perceptions about the complexity of the material (Fantaneanu et al., 2014). Other barriers may be more rooted in cognitive factors, especially difficulties with the spatial reasoning skills needed to make mental conversions between 2D images of the brain (e.g., from a magnetic resonance imaging study) and the 3D reality of neural structures (Brewer et al., 2012). To counter this, a number of instructors have created novel and engaging methods of helping students visualize 3D anatomical relationships, such as through the construction of clay models (Daniels, 1979; Estevez et al., 2010).

Dissection, particularly of sheep brains, is another commonly used and valuable technique for allowing students to explore the 3D anatomy of the brain (Grisham, 2006). However, either economic or logistical factors may prohibit traditional dissections in many undergraduate classes. Alternatives, particularly humorous alternatives that may be useful in reducing students' anxieties related to the course material (Masters and Christensen, 2000), may therefore be beneficial. This paper presents a brief, low-cost, flipped classroom exercise in which students work in teams to 'dissect' snack cakes and present their 'findings' using neuroanatomical terminology. In a flipped class, traditional lecture materials are presented outside of class (e.g., in an online video) while class time is reserved for problem solving activities, often in groups. The efficacy of the model has been demonstrated in a number of settings (Bishop and Verleger, 2013), and it has been suggested that the approach may be particularly successful in teaching neuroanatomy (Krebs et al., 2014).

The specific goals of the activity were to: 1) introduce students to basic neuroanatomical terminology, 2) give students practice in visualizing complex, 3D structures using 2D images (e.g., with coronal, axial, and/or sagittal sections), and 3) give students practice utilizing anatomical terminology to describe their observations. More broadly, the activity was designed to reduce students' anxieties about neuroanatomy, to increase their confidence in their ability to learn the material, and to help them begin to form peer-networks that may foster success (Hall et al., 2013; Hall et al., 2014).

The author presented the activity to a survey-level *Brain & Behavior* course. This course satisfies a requirement for the Psychology major and therefore enrolls students with varying levels of interest and experience in neuroscience and biology. Students were given the option to complete an anonymous online evaluation of the exercise and separately, to complete an anonymous online anatomy quiz assessing their learning.

MATERIALS AND METHODS

- Chocolate and vanilla snack cakes (with an icing 'olfactory organ' added by the instructor to indicate the anterior and dorsal aspects of the 'organism'), one cake per ≈3 students
- Paper plates and plastic knives for 'dissections'
- Dissection 'manuals' and assignment (see Appendix A)

Methods

The exercise was presented during the first full class period of the semester at the start of a unit of two, ninety-minute sessions that introduce basic neuroanatomy. Prior to the class, students were instructed to watch a brief (≈13-minute) online lecture (created with free software from Screencast-O-Matic, http://www.screencast-o-matic.com) that covered basic anatomical directional terms (e.g., anterior, posterior, dorsal, ventral, superior, inferior, medial, lateral, unilateral, bilateral, contralateral, ipsilateral, distal, proximal) and brain sections (e.g., coronal/frontal, axial/horizontal, sagittal). Students were told that this video would prepare them for dissections they would perform in the subsequent class, while leaving the specific *nature* of those dissections up to their imaginations [for a similar approach, see (Masters and Christensen, 2000)].

At the start of the class session, the instructor (who arrived to class wearing a lab coat, gloves, and surgical mask) revealed to students that they would actually be dissecting two 'subspecies' (chocolate and vanilla) of snack cakes. The students then received the dissection 'manuals' (see Appendix A for manual and the complete assignment). The students' goal was to work in groups to delineate the 3D distribution of the cream filling of the snack cake using a combination of coronal, axial, and sagittal slices. They were required to figure and label each slice using appropriate anatomical terminology. Following this, they wrote a one paragraph summary of their 'findings' using anatomical terminology and then compared/contrasted their work with a group who had dissected the other 'subspecies' of cake. Following this, groups volunteered to share their results with the class as a whole. The exercise required ≈ 30 minutes of class time. Appendix B contains notes on snack cake 'anatomy' and further suggestions for implementing the exercise.

Student Sample and Assessment

The author presented the exercise as part of standard classroom practices to undergraduate students in a survey-level course (enrollment=31, 26 female) at a liberal arts college. Students were primarily freshmen and sophomores (≈68%). Students were invited to provide optional feedback on the exercise by completing two anonymous online instruments, the primary purpose of which was to allow the instructor to quickly obtain feedback data for assessing and improving his own pedagogy. The first instrument consisted of a 7-item feedback questionnaire (see Table 1) with potential responses ranging between 1 ("strongly disagree") and 5 ("strongly agree"). The author was interested in the percentage of students who felt the exercise met the goals described above, so a mean rating of 4 ("agree") was considered to indicate a positive result. The second instrument was a 7-item multiple choice quiz that presented students with images of coronal, axial, and sagittal slices of the human brain. Students were asked to identify the slices and/or determine appropriate directional terms based on the orientation of the individual slices. Twenty-two students completed the questionnaire and 21 completed the anatomy quiz.

RESULTS

Feedback Questionnaire Data

Table 1 presents means and standard deviations of student responses to the online feedback questionnaire. Student ratings were favorable overall. In particular, 95.45% of respondents "agreed" or "strongly agreed" (score≥4) that the exercise "…helped me learn neuroanatomical terminology." 90.91% agreed or strongly agreed that the exercise was "…useful practice in visualizing 3D structures in two dimensional sections", and that it "…increase[d] student's confidence in their ability to learn neuroanatomy." 85.71% agreed or strongly agreed that the activity "…increased my interest in learning more about neuroanatomy in general." Students also generally agreed (*M*=4.23, *sd*=.75) that the activity was "…engaging…", and that it was a useful way to "…break the ice..." with other students in the class (*M*=4.05, *sd*=.58). Importantly, no respondents "disagreed" or "strongly disagreed" (score≤2) with any item on the questionnaire.

Online Anatomy Quiz Results

To ensure complete anonymity of respondents, quiz results were disaggregated (the number correct/incorrect responses for each question were separately analyzed rather than looking at each student's grade). Overall student accuracy was good. The mean percentage of correct responses across questions on the quiz was 85.03 (*sd*=15.17). One quiz question (identifying medial/lateral directions on a coronal section) proved more difficult (52.38% correct). The mean percentage of correct responses across the other six items was considerably higher (*M*=90.48%, *sd*=.05).

DISCUSSION

The data suggest that the video/dissection exercise accomplished its goal of introducing undergraduate students to a topic they often find somewhat daunting. The majority of respondents found the activity to be engaging, that it increased their interest in learning about neuroanatomy, and perhaps more importantly, that it increased their confidence in their ability to successfully do so. In addition, the data suggest that the exercise accomplished its goal of teaching basic neuroanatomical terminology and affording students practice in visualizing 3D structures using 2D sections. More than 90% of respondents agreed (or strongly agreed) that the exercise was useful in these respects. This was further supported by students' strong overall performance on the online anatomy quiz. In all, these data suggest that the exercise may have helped alter student perceptions about learning neuroanatomy and helped them begin to develop a knowledge base useful to all neuroscientists.

It should be noted that as this exercise represented standard educational practices, it was not possible to include a control group. It is therefore not possible to determine (from these data) if this exercise was more effective in teaching anatomical terminology than other, more traditional methods such as in-class lectures.

Item	Mean (SD)
The activity:	
"…was engaging"	4.23 (.75)
"…helped me learn neuroanatomical terminology"	4.32 (.57)
"…useful practice in visualizing 3D structures in two dimensional sections"	4.27 (.63)
"…increased my interest in learning more about neuroanatomy in general"	4.00 (.55)
"…increase[d] student's confidence in their ability to learn neuroanatomy"	4.18 (.59)
"…made me more excited to take this class"	3.86 (.77)
"…was a good way to 'break the ice' with classmates'	4.05 (.58)

Table 1. Presents the mean (SD) response for each item on the feedback questionnaire. Responses were given on a scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). A score of 4 corresponded with "agree."

However, the interactive, humorous nature of the exercise may offer advantages above and beyond its purely pedagogical outcomes.

For example, the exercise may have helped set a more collegial tone for the semester. Respondents generally agreed that the exercise was a useful "icebreaker" for working with other students in the class, and indeed 64% of respondents agreed or strongly agreed that the exercise increased their excitement about taking the class in general. While this number is not overwhelming, it could be argued that given the exercise's low demands in terms of class time (≈25-30 minutes) and resources (<$10 for 30 students), any increases in student engagement or excitement could be important.

More broadly, these data support previous reports [e.g., (Masters and Christensen, 2000; Russell et al., 2013)] suggesting that exercises that encourage students to examine topics in neuroscience from a humorous, informal perspective may be useful in engaging potentially nervous individuals. This underscores that humor is a useful tool for college educators, including for reducing student anxiety about coursework (Torok et al., 2004), an effect that may be particularly important in classes that some students "dread" (Kher et al., 1999).

In conclusion, the data suggest that this brief flipped classroom exercise could be a useful tool for educators who introduce neuroanatomy to undergraduates. Due to its low cost, it would be relatively easy to implement in larger classes, including large lectures where it may often be challenging to encourage students to learn actively. Similarly, it would be easy to broaden the exercise by requiring students to write hypotheses prior to their 'dissections,' to diagram and discuss the merits of different dissection plans, or to increase inter-group interactions by requiring students to compare/contrast different varieties or brands ('species'?) of snack cakes.

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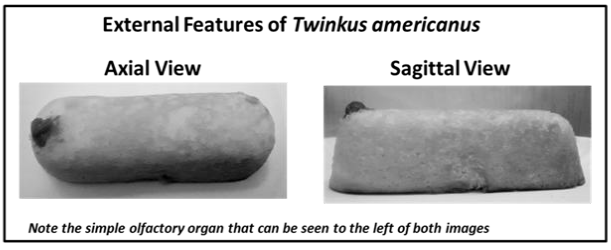
APPENDIX A

Text of the 'dissection manual' and assignment for the activity.

Dissection of the North American Snack Cake, *Twinkus americanus*

Overview: Despite its hardiness and ubiquity in lunchboxes throughout the continent, *Twinkus americanus* and its subspecies *Twinkus americanus chocolatus* remain poorly understood. Externally, the creatures exhibit simple bilateral symmetry and possess a rudimentary olfactory organ on the dorsal, anterior portion of the body. It has been long agreed that these creatures biosynthesize delicious cream filling, but the specific anatomical distribution of the cream is not clearly documented. Today, we will rectify this gap in the literature.



Goal: Explore and document the three dimensional distribution of cream filling in the *Twinkus americanus*

***Actual* Goal:** Gain familiarity with anatomical terminology and with viewing complex structures using two dimensional sections, as well as with reporting your 'results'

Methods:

In the next 15 minutes, you should

1) Place your teams' specimen on the dissecting plate (ventral side down). Draw arrows on your plate to indicate the following directional terms: anterior/rostral, posterior/caudal, medial, & lateral. Each group member should add one of the arrows.

2) Plan the dissection of your specimen. Use at least one each of axial/horizontal, coronal/frontal, and sagittal slices.

3) Conduct your dissections. For each slice, draw/record your findings on the back of this page. In other words, draw at least one of each of the following cross-sections: axial, coronal, sagittal.

4) Complete the other questions/exercises you'll find on the back of the page (Be prepared to share these results when we're done with the 'lab').

5) Eat the remains of your *Twinkus* if you are so inclined.

Exercises

1) Draw the results of your dissections below (or on a separate sheet). Clearly label each figure as axial/horizontal, coronal/frontal, sagittal.

- For each, include appropriate directional terms (e.g., dorsal/ventral, anterior/posterior, medial/lateral)

2) Would it have been possible to adequately describe the distribution of cream had you only used a midsagittal slice? Why or why not?

3) In one paragraph, describe your results. Be sure to use appropriate directional/anatomical terms, including at least two of the following terms: bilateral, contralateral, ipsilateral, proximal, distal

4) Find a group who had the other subspecies of *Twinkus* (e.g., if you had the typical *Twinkus*, find a group who had *chocolatus*). Share your results, then compare and contrast.

APPENDIX B

Notes on Snack Cake 'Anatomy' and Implementing the Exercise

The 'North American Snack Cake' has three separate pockets of cream filling injected through the midline of the 'ventral' surface. The pockets are roughly bilaterally symmetrical and are distributed approximately equally along the length of the cake. This arrangement is useful in that it requires students to use slices from different orientations (e.g., a combination of sagittal, axial, and coronal sections) to fully document.

The distribution of filling in the chocolate 'subspecies' is (to the author's knowledge) identical. However, differences in manufacture, storage, and/or handling might lead to variation from cake to cake. Students may note this in their individual 'dissections' or particularly when comparing results across groups ('species'). This could provide a useful starting point for discussing the considerable individual differences that can be seen in human brain anatomy and that these differences are not *necessarily* related to meaningful behavioral or cognitive outcomes.

While the distribution of filling in the cakes could superficially be compared to the ventricular system, it does not directly resemble any human brain structure. This is a potential point of confusion for students, as is the fact that while both the snack cakes and brains are bilaterally symmetrical, the snack cakes are also symmetrical along the anterior/posterior axis. As such, it would be helpful if

the instructor stressed that the skills and terminology the students are practicing are not specific to studying neuroanatomy.

It is possible that experienced students may initially find the exercise overly simplistic, particularly given that it takes place early in the semester (before they might be used to the tone of the professor). If the instructor senses reticence, it would be helpful to explain that one of the major goals of the exercise is to reduce anxiety in students with less of a background in the sciences. It would also be helpful if the professor assigned students to particular teams, ensuring a mix of experience and comfort levels.

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