https://doi.org/10.36315/2025v1end055
p-ISSN: 2184-044X e-ISSN: 2184-1489 ISBN: 978-989-35728-7-0 © 2025

THE CONNECTION BETWEEN GUT-BRAIN AXIS, ANXIETY AND LEARNING: A MICRO-SCENARIO FOR HIGH SCHOOL STUDENTS

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Abstract

The gut-brain axis is a term used to describe the reciprocal connection between the central and the gastro-intestinal nervous system. It plays a crucial role in linking the emotional and cognitive brain functions with the peripheral intestinal ones. Degradation of this communication can lead to anxiety, mood disorders and impaired learning ability. By acknowledging the increased anxiety levels and learning difficulties of students in secondary education, this lesson plan aims to educate them on the importance of the gut microbiome in emotional and intellectual processes, while informing on ways to protect and restore it. In the context of a biology course, students will navigate through an online learning environment that provides insight into the human microbiome. After being inspired by an art exhibition and a related poem, students will create an artistic representation of the gut-brain axis. Moreover, a brainstorming session will tap on the factors that affect the gut microbiome, such as breastfeeding, nutrition, exercise, sleep and smoking/vaping. The impact of excessive antibiotic use on the balance of the intestinal microbiota will be showcased through an online game. In addition, the role of the gut-brain axis in maintaining a healthy brain will be emphasized through a theatrical improvisation activity that incorporates healthy eating habits, a short exercise routine and a set of relaxation techniques. Finally, students will be introduced through a Jigsaw activity to the cutting-edge biotechnological approach of fecal transplants for restoring gut microbiota. The current teaching intervention will be assessed through self-reflection, open discussion and online reports.

Keywords: *Gut-brain axis, gut microbiome, active learning, STEAM education, secondary education.*

1. Introduction

Recently, there has been an increasing interest of the scientific community on the bi-directional communication between the gut and the brain that is referred to as the gut-brain axis (Carabotti, Scirocco, Maselli, & Severi, 2015). The medical community has acknowledged the significant implications of gut-brain axis on mental health (Skonieczna-Żydecka, Marlicz, Misera, Koulaouzidis, & Łoniewski, 2018). Moreover, multiple studies suggest a strong correlation between gut-brain interactions and academic performance (Chakrabarti et al., 2022). However, to the best of our knowledge this is a topic that has been heavily overlooked, even within the medical education context (Simons et al., 2022). To address this educational disparity, this lesson plan incorporates STEAM (Science, Technology, Engineering, Art, Math) and active learning approaches that raise awareness, while boosting research thinking and science communication skills.

2. Methodology

Subject: Biology – Topic: The interplay of gut-brain axis, anxiety and learning – Age Group: Teenagers – Time: 90 minutes.

2.1. Educational goals

This lesson aims to: 1) Boost science and technology literacy skills of secondary education students. 2) Promote active learning, research thinking, and collaboration. 3) Develop science communication skills. 4) Educate on the gut-brain axis and its interconnectedness to learning, education, emotion, stress and anxiety. 5) Inform on the factors that influence the gut-brain connection. 6) Raise

awareness on misuse of antibiotics and antimicrobial resistance. 7) Introduce microbiome restoration and relevant applications. 8) Raise awareness on habits and behaviors that protect gut and brain function.

2.2. Materials

Video projector, IT (Information Technology) classroom with Internet connection, containers with labels, a zip-lock bag, shower gel, pom-poms, spaghetti, beans, chickpeas, craft eyes, craft sticks, a box, and three ribbons.

2.3. Procedure

This lesson plan spans two teaching hours. During the first hour, the gut flora and the gut-brain axis are introduced to students. In the second hour, students explore the interplay between gut-brain axis, anxiety and learning, and the factors that influence this axis. Finally, assessment of the teaching intervention occurs, by means of self-reflection, a plenary discussion and student experience evaluation.

2.3.1. 1st Phase: (time: 45 min). 1st micro-activity (time: 20 min). Virtual representation of microbe and microbial community behavior via an online simulator.

1. Students are directed to an online microbiome simulator by Learn.Genetics, a genetic science learning center (https://learn.genetics.utah.edu/content/microbiome/simulator/).
2. We ask students to observe the virtual microbes and to describe over spreadsheets how the virtual microbial community behaves.
3. Students are requested to report on how virtual microbes respond to changes in their environment that cause a temporary or permanent effect.

2nd micro-activity (time: 25 min). Introduction to the gut-brain axis.

1. First, students are requested to explore an online exhibition, namely the *Mind the Gut* by the University of Copenhagen (https://www.museion.ku.dk/en/mind-the-gut_/). In more detail, students navigate posters, videos, artwork and narratives so to appreciate the complex connection between mind and gut via the threefold of science, art and history.
2. Second, students watch a video by the Bohorquez Laboratory, Duke University (https://youtu.be/oym87kVhqm4?feature=shared). We then ask them to describe on their spreadsheets: (i) the recently discovered pathway that bridges the gut with the brain, (ii) how this can become a target by pathogens and (iii) how this information may be employed to develop therapies.
3. Next, students engage in the active reading of a poem (https://drive.google.com/drive/folders/1NhaQmFcb6wjG3E5XB3l0ELiCwdyW6oda) inspired by microbial role and function in the human body and how the latter is affected by lifestyle choices. We ask students to attempt rewriting parts of it, so to communicate more effectively the science involved, and to brainstorm on provisional titles of the reworked poems.
4. Subsequently, we provide students with labeled containers that correspond to elements of the gut-brain axis and ask them to produce an artistic representation of this axis. The provided materials are as follows; the zip-lock bag represents the intestine, the shower gel the stomach fluid, the pom-poms the bacterium *Bacteroides fragilis*, the spaghetti the bacterium *Bifidobacterium animalis*, the beans the bacterium *Enterococcus faecalis*, the chickpeas the bacterium *Escherichia coli*, the craft eyes the probiotic *Lactobacillus*, the craft sticks the probiotic *Bifidobacterium*, the box represents the brain and the ribbons the three pathways connecting the gut with the brain.
5. Finally, students present their artwork in the classroom.

2.3.2. 2nd Phase: (time: 45 min). 3rd micro-activity (time: 10min). Link of gut health to cognition, mood and memory.

1. Students watch a BrainFacts.org video on the connection between the gut microbiome and the brain (https://youtu.be/5S-eOHfbwa8?feature=shared).
2. Subsequently, they describe on their spreadsheets the relationship between gut, serotonin, stress response and memory.
3. Students offer their thoughts on the influence of gut microbiome on mental health and cognition.

4th micro-activity (time: 30min). Nutrition and other factors influencing the gut-brain axis; antibiotics, antimicrobial resistance and effective treatments.

1. Students brainstorm on the factors that influence gut microbiome (such as diet, exercise, sleep, smoking/vaping and breastfeeding), using concept mapping as a teaching method.

2. Students watch a Ted-Ed video (https://youtu.be/1sISguPDlhY?feature=shared) and make notes of the foods that promote a healthy gut; bacterial diversity, balance, growth, as well as prevalence of probiotic bacteria. They also note the influence that lifestyle has on gut microbiome and how this supports body functions.
3. In an improvisation activity, students act out lifestyle habits that support healthy gut function, i.e., wholesome nutrition, physical activity, stress management, good quality of sleep, relaxation techniques.
4. Students are directed to *Agent Antibiotic,* an online game by *Learn. Genetics* site (https://learn.genetics.utah.edu/content/microbiome/agentantibiotic/). They note down on their spreadsheets observations on bacterial infections, the impact of antibiotics treatments on intestines, side-effects of treatments, the role of probiotics, new effective treatments and, importantly, antimicrobial resistance, its implications on health and effective strategies to avoid it.
5. Finally, in a jigsaw activity (Chopra et al., 2023), the fecal transplants treatment is addressed. Students work in mock- expert groups, each responsible for a key issue on this topic, such as mechanisms, applications, challenges, etc. Then, each team engages in teaching, thus promoting peer instruction.

2.3.3. Evaluation (time: 5 min). Assessment of student understanding and experience.

1. Students engage in self-reflection, which they note on their spreadsheets. This is based on the following prompts: “Today I learned”, “Today I felt”, “Today I experienced”.
2. A plenary discussion is held on the content of the lesson, the activities employed and whether learning objectives were accomplished.
3. Students participate in a Mentimeter poll (https://www.mentimeter.com/) to offer their insight into student experience, e.g. “How did you enjoy the lesson?”, “Did you like the material?”, etc.

3. Conclusions

Data collection on learning outcomes and student experience by means of student feedback will help shed light on the effectiveness of the described lesson plan (Carless & Boud, 2018).

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