Using Collaborative Projects to Promote Active Learning of Microbial Skin Diseases and Their Impact on Everyday Lives

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Abstract

One of the most daunting aspects of introductory clinical microbiology is learning details about a vast number of different microbial diseases that can infect humans. Each of these diseases has different causative agents, diagnostic procedures, and optimal treatment options. Allied health professions, such as nursing, dentistry, and clinical lab science use this integrated knowledge on a daily basis as they work with patients, physicians, and clinical staff. This lesson plan uses collaborative learning to demonstrate the impact and importance of microbial disease in everyday life. Designed to summarize and give context to prior learning, students research and present key findings about an infectious disease of the skin to classmates. The lesson requires each student to contribute within their group to research a microbial disease as if they were clinical professionals. This lesson is best suited for use in the last month of class, as it requires students to activate prior learning to describe the progression, diagnosis and treatment of their disease in the context of course materials. Learning about microbial diseases and the impact on everyday life helps students appreciate the relevance of concepts learned throughout the semester.

Learning Goals

Students will:

◊ understand the importance of clinical laboratory testing in medical care.
◊ know how a variety of skin diseases are diagnosed and treated.
◊ understand the value of communication in science and medical care.

The lesson learning goals align with the following society-generated guidelines.
◊ From the ASM Recommended Curriculum Guidelines for Undergraduate Microbiology Education:
  » #30. Ability to communicate and collaborate with other disciplines
    - Effectively communicate fundamental concepts of microbiology in written and oral format.
    - Identify credible scientific sources and interpret and evaluate the information therein.

Learning Objectives

Students will be able to:

◊ describe a microbial disease on the basis of pathogen, virulence factors, transmission, clinical lab testing, disease caused, prevention, and treatment and care.
◊ research a microbiological topic using credible sources and databases (at least two of the three research citations should be from primary sources).
◊ work collaboratively within a group of peers and present their research findings in a professional setting.
◊ communicate with peers, professionals, and the general public.
◊ describe the impact of microorganisms on everyday life.
INTRODUCTION

The collaborative learning approach involves groups of learners working together to achieve a shared learning goal (1). This method of learning not only affects academic performance positively, but has social and psychological benefits. According to a review by Laal and Ghodsi (2), collaboration can provide social supports for learners, boost critical thinking skills, and actively engage students. They emphasize student needs of community building and positive interdependence in a variety of contexts. Lessons focused on student groups working on a shared project with embedded formative assessment led to student learning in microbiology and nursing labs (3–5).

Advanced microbiology lessons in microbial ecology (6) and immunology (7) have used collaborative techniques, such as think-pair-share and jigsaw to good effect.

Active learning increases retention and improves grades, particularly for underrepresented minority students in Science Engineering and Mathematics (8). The meta-analysis by Freeman et al. (8) demonstrated that students in lecture-based classrooms are 1.5x more likely to fail (33.8% for lecture-based vs. 21.8% for active learning classrooms). Employing collaborative methods to promote active learning in microbiology for nursing students creates opportunity to learn together to achieve a common goal. This skill is required in taking care of patients as they have to always look for signs and symptoms and collect specimens for further laboratory analysis.

In the healthcare profession, a team effort is often required to care for patients. Knowledge of the possible microbial diseases and the cause and prevention of infection are critical components of patient care. Nursing school programs often include collaborative classrooms in labs, with students learning together and often serving as patients in simulations (9). Key benefits of collaborative learning are the development of active listening, task specialization, and positive interdependence skills. This activity, used in undergraduate microbiology classrooms enables students to practice these skills before entering nursing programs (10, 11). These so-called soft skills of active listening and collaboration are viewed positively by nursing school admissions committees moving to holistic admissions review (12). This lesson reemphasizes the importance and the impact of the various microbial concepts learned throughout the semester.

Nurses are responsible for collecting patient specimens and sending them to the laboratory for diagnosis. Clinical lab personnel then call critical results to nurses and physicians so they can adjust treatment or other considerations for their patients based on laboratory results. Understanding the microorganisms responsible for different diseases will help in their professional career as they care for patients and look for signs and symptoms.

In this learning module, students collaboratively choose a disease to investigate, describe this disease in terms of symptoms and treatment while also focusing on the microbiology of the pathogen (virulence factors, diagnoses, transmission). The student peer groups split up work, leveraging student strengths and practicing literature review and presentation skills. These are valuable skills that complement the content knowledge about viruses, bacteria, and fungi that cause skin diseases.

Intended Audience
This lesson plan can be incorporated into introductory microbiology coursework. This includes non-majors and allied health microbiology courses. With minor adjustments to timing, it could also be used online. This lesson was created and tested in an undergraduate microbiology course for pre-nursing students.

Required Learning Time
This lesson fits well into the last 3–4 weeks of the semester, as this time is typically dedicated to the learning of the relationships between particular diseases and the etiologic agent causing them.

Prerequisite Student Knowledge
Since the students will be researching microbial diseases or pathogens they should be familiar with basic microbial terms, diagnostic methods such as Gram stain and other differential stains, and methods of identification. Examples of methods of diagnosis include use of microscopy to identify microbial characteristics after staining, and use of differential media to isolate and characterize pathogens of interest. Students should be familiar with the specimen collection and handling methods in diagnostic microbiology as well as the importance of the host immune system and the virulence factors that pathogens have to cause disease. Since this lesson is typically used at the end of the term, students should have already learned background knowledge of the signs and symptoms of different diseases as well as the prevention and treatment of diseases.

The students will be presenting their findings in an oral presentation and submitting a PowerPoint (or other presentation software, such as Canva) and should have basic skills in slide construction and using collaborative software (e.g., Google Docs).

Prerequisite Teacher Knowledge
Content knowledge includes general microbiology and diagnostic microbiology.

Instructors will need knowledge of microbial terms and diagnostic techniques. Instructors should also be familiar with the diseases and etiological agents. They should also be familiar with virulence factors and disease progression. This lesson works well if the instructors adopting it are familiar with a variety of collaborative and active learning techniques (13), such as think-pair-share (14) or jigsaw teaching methods that enhance learning.

SCIENTIFIC TEACHING THEMES

Active Learning
This active learning collaborative approach engages through interaction to achieve the common goal of teaching their classmates and instructor about a skin disease. This lesson works well as the last activity of the semester because it synthesizes many different components of nursing microbiology coursework. Students describe the symptoms, sample collection and lab work, diagnosis and common treatment plans used to diagnose and treat a disease that affects the skin. It is equivalent to an exam, giving students an alternate mode of summative assessment. In this project,
Using Collaborative Projects to Promote Active Learning of Microbial Skin Diseases and Their Impact on Everyday Lives

Assessment

We assessed prior student knowledge with a pre-test that measures student understanding of microbes, the skin as an ecosystem, science communication, and key clinical testing and treatment options (Supporting File S1). When students were preparing their presentations, they received frequent feedback and guidance based on the rubric for the assignment (Supporting File S5). Each student group gave a presentation that was assessed using the rubric for their grades. The post-test (Supporting File S1) for this lesson was graded and replaced a unit quiz.

This exercise also included several opportunities for formative assessment, both from the instructor and peers. The instructor was available to answer questions and had access to their collaborative shared digital folder. Students could ask questions in class, on notes included on document drafts, and via e-mail. The instructor provided feedback throughout the preparation process and checked in with groups at least once each week.

Inclusive Teaching

The lesson described is a collaborative group project that promotes active learning among students. They work together and all have a common goal to achieve. The underlying premise of collaborative learning is the fact that there is an expected consensus to achieve together through cooperation. Students work together to teach the rest of the class about a disease. Casting students in the role of educator is a way to emphasize learning over simply studying about a subject. This deeper learning has been shown to increase student engagement, performance, and sense of belonging in a STEM discipline (17–19). It increases performance in STEM, and closes the achievement gap seen in underrepresented students taking introductory science courses (20). A recent study reported that first generation students have lower preference to work alone than non-first generation students (21). Furthermore, putting the students in teacher-assigned groups further discourages exclusionary clique forming, provides an inclusive environment for students from marginalized groups, and is part of collaborative learning best-practices (22, 23).

LESSON PLAN

Learning about microbial diseases and their impact on everyday life helps students appreciate the relevance of concepts learned throughout the semester. This lesson is typically completed late in the semester, as it takes multiple weeks to complete (Table 1). At the start of the work, the class briefly reviewed various microorganisms that cause skin infections. These infections can be as simple as acne and as complex as fifth disease. While we used Chapter 19 of the Bauman “Microbiology Diseases by Body System” book, similar information can also be found in OpenStax Microbiology’s Chapter 21 (Skin and Eye Infections) or other similar non-majors microbiology textbooks.

Day 1

Students were assigned to groups of 5–6 to work together on the “Skin Disease Project” which is described in supporting material (Supporting File S2). We began this lesson with a brief lecture outlining of diseases of the skin (Supporting File S3). The instructor uploaded the lecture notes for this presentation to the learning management system (Canvas). Students reviewed the topics, chose two diseases indicating their first and second choice on a shared document (Google Doc), and signed up for a presentation time.

Day 2

Students sat together with group members to discuss their research projects. This discussion included division of labor as students would need to research their disease, its causative agent and virulence factors, methods of specimen collection, preventative measures, patient care, and treatment options. Each group was reminded to sign up for two diseases by midnight of the second day. The following day, the instructor assigned topics based on each group’s first choice where possible. If two groups picked same topic as their first choice, the first group to indicate interest would get that topic and the second group was assigned their second choice. After being assigned a topic, all groups had the opportunity to change their topic within 3–5 days. These changes were rare and typically the result of difficulties researching details, such as diagnostic measures, patient care, or common treatments of their disease. The instructor circulated throughout the room during this work time, answering questions about presentation formatting, giving literature search advice (expanding their Google Scholar searches to include Web of Science and introducing the class to the university library resources—these will vary with institution).
Day 3
Students sat in their groups and discussed their research findings. The instructor circulated throughout the room, answering students’ questions. At the end of the class period, the instructor led a brief question and answer session to identify common difficulties shared between groups. It is here that students typically discovered the challenges of researching specimen collection and clinical lab protocols. One common question was “what is meant by primary literature?”, which is the entry point to a short talk differentiating primary and secondary sources (24) and reviewing material from their assignment handout. We also posted a short video explaining the difference on Canvas, for students to reference as they continued their research projects: “Using Primary & Secondary Literature.”

Research Week (Days 4–6)
Students dug deeper into their research topic by summarizing three research papers, with at least one being a primary paper. These primary papers typically described discoveries about pathogenesis, diagnosis, or treatment. In addition to describing an infectious skin disease from symptoms to treatment, students also found a relevant case study describing their disease. These case studies could be from their textbook or from a medical or nursing journal, such as the New England Journal of Medicine (NEJM). Students could use the advanced search function at NEJM, type their disease in the search bar, and restrict the results to the “Clinical Cases” article category to find cases of their disease that doctors have reported. As students found their case study and investigated the impact of their disease on a real patient, they made connections between course content and the impact of infectious disease on everyday life. As part of this lesson, each group set up a collaborative site to share research and collaborate effectively. The shared platform allowed students to interact asynchronously and schedule synchronous times as well. This was particularly important during the pandemic shut down. At the end of their first research week, students checked in with the instructor, gave a brief progress report, and received feedback.

Presentation Week (Days 7–10)
After the second week of research students presented their findings to the class. Each group’s final work was submitted as a PowerPoint presentation on Canvas before the group gave ~10–12-minute presentations. Each student also submitted a peer review summary (Supporting File S4), detailing the collaborative effort made by members of their group. Groups had an optional pre-submission two days before their assigned time to receive feedback prior to their final presentations.

Online-Only Implementation
In Spring 2021, Dr. Ebomoyi used this assignment in a synchronously taught course that had shifted online from an in-person class. Teams presented online using Zoom, but any other conferencing platform would work. Alternatively, if this assignment is used in an asynchronous class, students can record their presentations using Canvas (Studio) or PowerPoint. If an online course is taught synchronously, groups could meet using breakout rooms, with the instructor(s) visiting each room individually, then bringing the entire group back for mini-lectures (Supporting File S2) or assignment instructions (Supporting File S3).

TEACHING DISCUSSION
In general, students responded well to this lesson. Since it is at the end of the term, it provides an opportunity for students to apply many of the concepts that they had been studying throughout the term. In a nursing microbiology course, this means differentiating between viral, bacterial, or fungal pathogens. It also means discussing methods used to collect and transport samples, tests done in a clinical lab, and common methods of treatment. Students practice their collaborative learning skills, as each group typically splits up the tasks. This gives the students the opportunity to teach the rest of their group about their findings, then teach the entire class about the disease they investigated.

During the first week of this lesson, students were placed in groups and worked together in class. They asked several questions about sources, which generally led to a short discussion of the value of both primary and secondary literature. They would also ask about which case study was most appropriate. While the textbook we used (“Bauman’s Microbiology with Diseases by Body System”) had embedded case studies for students to reference, there are several journals, such as the New England Journal of Medicine (NEJM) that have case studies that students could reference for their presentation. For example, searching NEJM for clinical cases mentioning “chickenpox” yields over 50 cases that mention chickenpox or shingles. Spending time searching for primary sources, case studies, and textbook information and organizing the information into a concise oral presentation improved students’ knowledge of microbial skin diseases and their role in everyday life (Table 2). It also improved their collaborative skills and ability to identify and use credible sources as measured by comparing student performance in a pre-test designed to assess the learning objectives for this activity (Supporting File S1). Interestingly, for a lesson that involved presenting a scientific topic, the students only slightly improved these skills (moving from 41% to 55% correct, p = 0.106).

This process could be used to investigate diseases from other organ systems as well. Many textbooks, including Openstax, organize their microbial disease chapters by organ system. Faculty could use this teaching strategy to teach students more about digestive system diseases, respiratory diseases, or nervous system diseases. The combination of in-class group work, literature review, case study reviews, and presentations allows students to put their microbiology skills into the context of patient care, demonstrating the impact of microbes in everyday life.

SUPPORTING MATERIALS
- S1. Promoting Active Learning of Microbial Skin Disease – Pre and Post Exercise Assessment
- S2. Promoting Active Learning of Microbial Skin Disease – Short Lecture PPT
- S3. Promoting Active Learning of Microbial Skin Disease – Student Assignment Handout
- S4. Promoting Active Learning of Microbial Skin Disease – Peer Review Form
- S5. Promoting Active Learning of Microbial Skin Disease – Grading Rubric for Presentations
ACKNOWLEDGMENTS

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REFERENCES

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Table 1. Lesson timeline. This lesson plan spans three class sessions as well as outside-of-class time for preparation and the collaborative activity. The last three weeks of the semester are devoted to this active learning project.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Estimated Time</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Preparation for Class</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-test</td>
<td>Students take short pre-test (Supporting File S1) on LMS.</td>
<td>20 minutes</td>
<td>Students take the pre-test at least 1 day before starting this lesson.</td>
</tr>
<tr>
<td><strong>Class Session 1</strong></td>
<td></td>
<td></td>
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<tr>
<td>Disease lecture</td>
<td>Instructor presents a short lecture (Supporting File S2) outlining a few typical diseases of the skin.</td>
<td>30 minutes</td>
<td>Brief introduction of diseases of the skin with emphasis on symptoms, virulence factors, and testing.</td>
</tr>
<tr>
<td>Set up collaborative peer groups</td>
<td>1. Organize class into groups of 5, alphabetically.</td>
<td>15 minutes</td>
<td>Each group should choose two diseases of skin as discussed in class and place their names to correspond with the date they wish to present. Students should read the entire guidelines and construct a plan on how to work collaboratively to complete all aspects of the assignment. Students should choose primary and secondary sources. References to types of primary and secondary sources are provided and discussed. Students sign in to their shared file folder and trade contact information.</td>
</tr>
<tr>
<td></td>
<td>2. Discuss expectations of research and collaborative activity.</td>
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<tr>
<td></td>
<td>3. Provide guidelines and learning objectives (see Supporting File S3).</td>
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<td></td>
<td>4. Review the rubric for the project (Supporting File S5).</td>
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<td></td>
<td>5. Set up the google collaboration on Canvas or other sites.</td>
<td></td>
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<tr>
<td><strong>Class Session 2</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer interaction</td>
<td>Brief meeting with groups to know their plans and ask questions.</td>
<td>30 minutes</td>
<td>Students share their findings about the two potential topics and ask questions within the group. Typically, this initial discussion reveals strengths and weakness of each option and sparks student interest as a result of their initial research. The instructor provides formative feedback.</td>
</tr>
<tr>
<td>Finalize choice of disease research topic</td>
<td>Students decide which disease they would like to focus on.</td>
<td>15 minutes</td>
<td>Each group decides which disease they would like to research more deeply, listing both their first and second choice on a shared document.</td>
</tr>
<tr>
<td><strong>Class Session 3</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer interaction</td>
<td>Brief meeting with groups to know their plans and ask questions.</td>
<td>30 minutes</td>
<td>Students share their findings about their research topic within their groups. Typically, specimen collection and clinical lab protocols are discussed. Another common question is about primary and secondary literature.</td>
</tr>
<tr>
<td>Short lecture</td>
<td>Open question and answer period about projects and short lecture that describes the difference between primary and secondary literature (review Supporting File S2).</td>
<td>15 minutes</td>
<td>Watch video “Using Primary and Secondary Literature”</td>
</tr>
<tr>
<td><strong>Class Session 4–6 Class Group Research</strong></td>
<td></td>
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<tr>
<td>Peer interaction</td>
<td>Group working time.</td>
<td>40 minutes</td>
<td>Students work in their groups during class time with instructor providing formative feedback.</td>
</tr>
<tr>
<td>Question and answer section</td>
<td>Students may have problems choosing a relevant case study or virulence factors of causative organism.</td>
<td>10 minutes</td>
<td>If their disease lacked a textbook case study, we would look in New England Journal of Medicine to find relevant case reports of patients with the disease.</td>
</tr>
<tr>
<td>Activity</td>
<td>Description</td>
<td>Estimated Time</td>
<td>Notes</td>
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<tr>
<td><strong>Class Session 7–10 Class Presentations</strong></td>
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<tr>
<td>Peer evaluation</td>
<td>At the start of this week, students submit peer evaluations of each other (Supporting File S4).</td>
<td>10 minutes</td>
<td>Students submit their peer evaluations before their presentation.</td>
</tr>
<tr>
<td>Submission for review before presentation</td>
<td>Ongoing work is submitted for review and suggestions by instructor via submission on Canvas.</td>
<td>10 minutes (optional), at least 2 days before presentations</td>
<td>Formative assessment with feedback. Students have option to submit work in progress for instructor to comment.</td>
</tr>
<tr>
<td>Group presentations</td>
<td>After discussing and working together, each group of students completes a 5-minute presentation.</td>
<td>40 minutes</td>
<td>Students present their work to peers and instructor.</td>
</tr>
<tr>
<td>Instructor discusses expectations</td>
<td>Instructor corrects any incorrect information and provides formative feedback.</td>
<td>15 minutes</td>
<td>Students submit their final work on the class LMS (Canvas) after presentation.</td>
</tr>
<tr>
<td>Peer review</td>
<td>Students complete peer review (Supporting File S4) which is part of the final grade.</td>
<td></td>
<td>Instructor and peers use a rubric to evaluate each presentation (Supporting File S5). Students submit evaluation of their peers as stated in initial instructions (Supporting File S3).</td>
</tr>
<tr>
<td><strong>Post Lesson Assessment</strong></td>
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</tr>
<tr>
<td>Post-test</td>
<td>Students take short post-test (Supporting File S1) on LMS.</td>
<td>20 minutes</td>
<td>Students take the post-test 1–2 days after completing the presentations.</td>
</tr>
</tbody>
</table>
Table 2. Demonstration of student learning. When 25 students were given the same short assessment (Supporting File S1) before and after the microbial disease project, they demonstrated significant ($p < 0.01$) learning gains as measured by paired $t$ test using JMP Pro (v16.0).

<table>
<thead>
<tr>
<th>Learning Objective</th>
<th>Points Possible</th>
<th>Pre-Test Score</th>
<th>Post-Test Score</th>
<th>$p$ Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>LO #1 Describe Microbial Disease</td>
<td>4</td>
<td>2.57</td>
<td>3.95</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>LO #2 Research a Topic Using Credible Sources</td>
<td>1</td>
<td>0.19</td>
<td>0.57</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>LO #3 Collaborative Work</td>
<td>0.5</td>
<td>0.36</td>
<td>0.5</td>
<td>$p &lt; 0.005$</td>
</tr>
<tr>
<td>LO #4 Communicating Science</td>
<td>1</td>
<td>0.412</td>
<td>0.55</td>
<td>$p = 0.106$</td>
</tr>
<tr>
<td>LO #5 Role of Microbes in Everyday Life</td>
<td>1</td>
<td>0.244</td>
<td>0.44</td>
<td>$p = 0.009$</td>
</tr>
</tbody>
</table>