



Lecture/In-class Exercise: Human Genetic Variation: A Flipped Classroom Exercise in Cultural Competency

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Resource Files:

1. Pre-class video
 - a. PowerPoint used to create video (if educator wants to produce own pre-class resource)
2. Human Genetic Variation: Hardy-Weinberg Equilibrium Worksheet
3. Human Genetic Variation: Hardy-Weinberg Equilibrium Worksheet Key
4. Interactive case discussion PowerPoint for classroom use

Resource Description:

Our understanding of human genetic variation has deepened through the Human Genome (International Human Genome Sequencing Consortium, 2004) and International HapMap (International HapMap Consortium, 2005) projects, which gave us a high-resolution view of human genetic variation and ancestry. Applying this knowledge to the evaluation of ancestry-based genetic testing strategies, such as direct-to-consumer genetic testing, is an important component of the practice of culturally-competent medicine and a clinically relevant way to teach the foundations of population genetics, including Hardy-Weinberg equilibrium.

This population genetics interactive case discussion was created to emphasize the clinical relevance of population genetics as applied to a required flipped classroom module in the first year Medical Genetics course for medical students at the Boston University School of Medicine. A “flipped classroom” is an innovative model of learning that inverts the traditional teaching model by delivering didactic content through educational technology prior to the traditional lecture time slot and focusing class time on active exercises and higher order concept mastery (Bergmann & Sams, 2012). These trends facilitate deeper learning of the material and allow students to have more control over their learning. Although this was initially piloted with medical students, it would be appropriate to use with advanced undergraduate students as well as graduate students with an interest in the clinical applications of the science they are studying.

Resource Justification:

This resource is aligned primarily with the GSA’s core concepts in evolution as well as genetics and society.

Under the umbrella of the GSA evolution core concept, we challenge students to gain a working knowledge of how human migration throughout history distributed human genetic variation across the globe (session learning objective 1) and created pockets of isolated ancestral groups (session learning objective 2). We also challenge the students to work with the models that mathematically describe principles in population genetics (session learning objective 3, GSA core competency applying statistical methods), and these founding principles are introduced through the pre-class video.

We then ask the students to apply these principles to translational health issues related to genetic testing strategies, often times developed for specific populations of particular geographic ancestries. These concepts fall under the GSA core concept in genetics and society, and this also represents interdisciplinary application of the underlying science (a GSA core competency). Students gain experience applying these concepts to a translational context through the in-class cases, and the session learning objectives 4 and 5 delineate some of the clinical complications that can result when population genetics principles are not given due consideration.

Curricular design of resource:

All too often, deep learning is sacrificed for surface learning due to circumstantial pressures, such as time available for in class instruction (Alberts, 2012). By moving to a flipped classroom model, we can use valuable classroom time for active forms of engaging the students while designating the acquisition of basic knowledge as a task to be completed prior to class (Mazur, 2009). Implementation of this educational strategy has had far-reaching effects in terms of dramatically improved learning gains in conceptual and problem solving settings as well as a reduction of the achievement gap observed in many STEM classrooms (Crouch & Mazur, 2001; Haak, HilleRisLambers, Pitre, & Freeman, 2011).

In order to promote these goals, the flipped classroom modality has been adopted across a wide range of classrooms, from K-12 classrooms through higher education. A particularly popular approach to the flipped classroom is based upon the model put forth by Salman Khan, founder of the Khan Academy (Khan, 2012). In this model, the pre-class assignment takes advantage of technology to deliver a video lesson to the students as homework. Subsequently, a variety of active learning exercises can be used in the classroom setting to promote deep learning of the material. Because of the success of this educational model, leaders have proposed that we adopt this strategy more widely for higher education, including in undergraduate (Handelsman et al., 2004; Mazur, 2009) and medical settings (Mehta, Hull, Young, & Stoller, 2013; C. G. Prober & Khan, 2013; C. Prober & Heath, 2012).

Towards this end, we structured this educational activity in the framework of the flipped classroom model of instruction. In this case, the students learn basic population genetics principles through a pre-class homework assignment that introduces the foundational material (representing learning objectives 1-3). Subsequently, we explore the more applied, translational concepts (from learning objectives 4-5) through the interactive cases discussed in the class setting. By designing the class in this inverted orientation, we are able to make these concepts much more interesting and relevant to the students. This is a vital pairing that encourages students to think critically and translationally in the classroom. Furthermore, because of the emphasis on cultural competence in the case studies, we are able to promote rich discussion on some of the causes of health care disparities.

Session Learning Objectives:

By the end of this session, students should be able to:

1. Illustrate how historical human migration patterns have contributed to genetic variation observed in modern populations.
2. Differentiate between population subgroups defined by racial categories or geographic ancestry in terms of genetic variation.
3. Use the principles of population genetics (e.g. founder effect, Hardy-Weinberg equilibrium, selection pressure) to predict frequencies of alleles and genotypes in a given population.
4. Evaluate the significance of identifying the presence of disease alleles on the health care system and on individuals acquiring this information directly, in the absence of the guidance of a health care professional.
5. Assess the implications of evolving genetic testing technologies on yielding false negative results and the validity of the duty to re-contact concept.

Implementation Advice:

1. Materials
 - Students require access to computers with updated flash player or other media player.
 - Learning management system or basic course website: The mp4 of the pre-class video and other materials can be stored on these websites for student access.
 - Web module “RACE: Are we so different?” project developed by the American Anthropological Association (<http://www.understandingrace.org>, 2011): This educational resource includes a section that specifically explores human genetic variation and race. This expertly created interactive module includes information on the science of the complex relationship between race and human genetic variation, and it includes a quiz that the students can take to self-assess their understanding of this complex topic.
 - Classroom equipped with an LCD projector and an audience response system: Instructors can use electronic audience response systems such as Turning Point or iClicker, or if their institution doesn't have this technology available, class polling of answers can be accomplished using colored sheets of paper that students hold up in class to share their opinions. The advantage to using the electronic solution is that responses are anonymous to peers in this set up.
2. Length

The pre-class video is 30 minutes long. The recommended time frame for the in-class discussion is 1-1.5 hours.
3. Facilitator Tips

The facilitator of the in-class discussion does not necessarily need to be a faculty member of the Medical School but should be experienced in the concepts of direct-to-

consumer genetic testing, geographic ancestry, and population genetics. In our case, the discussion was led by a fourth year medical student with an interest in pediatric genetics and medical education.

4. Outline

- Students should view the population genetics video (resource #1) on-line at least the day before the planned discussion. We recommend using an associated graded assignment to ensure the students complete this exercise in preparation for class. Options to promote this include:
 - writing and submitting a question about the content
 - indicating aspects of the content that were new or review for them through a reflective writing assignment
 - including questions related to the content on regular class quizzes
 - assigning the worksheet associated with the video (resource #2) to be turned in for a grade. The timing of the related video segments is noted on the worksheets, and description of the calculation methods can be skipped if the student already has a working knowledge of the principles of Hardy-Weinberg Equilibrium.
- On the day of the discussion, the facilitator leads an interactive case discussion of current topics of population genetics and direct-to-consumer genetic testing employing the Powerpoint slides (resource #4) and audience response technology. Clicker-based audience response technology allows students to submit their responses to questions posed on the slides to allow for immediate polling of student understanding of topics. These responses can be displayed in real time and anonymously. Responses can also be collected by distributing colored sheets of paper or index cards to students for them to hold up in class for each answer choice.

Conclusions:

We were able to successfully implement the online video and interactive discussion in our class of 180 first year medical students. Our tips for success in facilitating a discussion of approximately 180 students include:

- Break students in auditorium into groups and ask for student opinions for discussion questions from within each group; this prevents a select group of students from dominating the discussion. This might be better accomplished in a large hall that can be filled with round tables, seating 6-8 students per table.
- Repeat questions and comments from the students so that all students in a large hall can hear the contributions of their peers. Alternatively, set the room up conference style with microphones in the aisles where students can move to be amplified for the discussion.
- Both of the suggestions above (the table tops and the microphones throughout the room) should be carried out in the longer class time frame of 1.5 hours rather than the abbreviated 1 hour version of this exercise.

Student engagement with the material during the discussion was high, and they raised many complex points related to the cases. There was rich discussion on the nature of health care disparities, the influence of for-profit genetic testing companies, and the limited preventative options available in genetic conditions. Feedback from course evaluations and a five student focus group suggested that even despite the methods used to engage all of the students, some students felt that this was too many people to have a successful discussion in which all viewpoints are heard. Students discussed the possibility of certain students not feeling at ease in such a large setting to share their viewpoints, particularly for some of the sensitive topics discussed here. A potential method to directly address this limitation would be to hold the discussion in a small-group format rather than in the large group setting.

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