Using Magnets and Classroom Flipping to Promote Student Engagement and Learning about Protein Translation in a Large Microbiology Class

Jennifer L. McLean* and Erica L. Suchman
Department of Microbiology, Immunology and Pathology, Colorado State University, Fort Collins, CO 80523

INTRODUCTION

Active learning advocates contend that when students do something they learn it better than if they just hear and see it (2). Therefore, we developed an activity that allows students to perform the process of bacterial protein translation using a hands-on model during a regular class period of a large enrollment (150 students) general microbiology course. Here, we combined a hands-on activity with a classroom flip, because classroom flipping has been shown to increase student attendance, promote higher engagement, and stimulate more than twice the learning (1). Students were asked to watch a 30-minute lecture video before attending class on the day of the activity. This allowed us to dedicate an entire class period to the activity and to formative assessment. According to student feedback, most students liked the flipped class format, and most thought the activity helped them to learn translation. Overall, the activity and classroom flip presented here were useful for allowing students to interact with challenging course material in a way they found helpful to their understanding.

PROCEDURE

Flipped lecture

A 30-minute lecture video was created using Echo 360 software and posted on the class website. The video shows the instructor giving a PowerPoint lecture (Appendix 6) covering the step-by-step process of protein translation in bacteria. After watching the lecture, the students should understand how ribosomes “read” mRNA to form a growing peptide using tRNA and the genetic code, and they should be able to calculate the number of ATP/GTP expended during each step. Students were asked to watch the lecture video before coming to class on the day of the activity.

In-class protein translation activity

This activity was designed for a 50-minute class period and could be carried out in almost any classroom type, including lecture halls with or without desk surfaces. At the beginning of class, students are to form groups of no more than three to allow each member the chance to manipulate the kit pieces. Each group receives an Instructions Sheet – Student Copy (Appendix 1), a 12” × 12” metal board, and one kit envelope containing the magnetic pieces (Fig. 1). The Instructions Sheet – Student Copy lists the kit contents, provides the DNA sequence encoding the protein, and walks the students through the process of translation in bacteria. The caveat here is that students will need to have received a previous lecture about transcription in order to know how to correctly choose between the two mRNAs included in the kit. The metal board can be purchased at home improvement stores, and duct tape should be applied to the edges of the metal board if they are sharp. The magnetic pieces were generated in Word and printed on magnetic printer paper (3270 Avery Magnet Sheets) using an ink jet printer, as laser jet printers can damage the magnetic paper (see Appendix 5 for templates). The amino acids and tRNAs have Velcro strips strategically placed on them to allow the students to attach the correct amino acid to the correct tRNA and to form “peptide bonds” between amino acids on the growing peptide chain (Fig. 1). The 50S ribosomal subunit has a defined P-site and an A-site onto which the tRNAs can be placed such that the tRNA anti-codon lines up perfectly with the codons in the mRNA.

Groups should be given 25 minutes to pick the correct mRNA and translate a protein spelling something in English using the one-letter amino acid code. There is a blank at the end of the sheet for students to write down their translated protein and calculate the number of ATP/GTP expended. It is recommended that the instructor walk around the classroom during this time and interact with struggling students. There are several distractors built into this activity (discussed in Instructions Sheet – Instructor Copy, Appendix 2), and depending on the students’ backgrounds in protein translation, many may experience difficulty getting started. An example of a distractor is an AUG sequence placed before the Shine-Dalgarno (AGGA) sequence. Many
students will begin making codons at this AUG rather than at the first AUG following the AGGA sequence.

Once 25 minutes are up, most of the groups should have successfully translated a protein that says “RAMS.” The remaining class time can be dedicated to the iClicker Quiz (formative assessment; Appendix 4), which takes about 20 minutes, leaving 5 minutes for clean-up.

CONCLUSION

Protein translation is a dynamic process that is difficult to convey on a static piece of paper or slide. We have developed an in-class activity that can be used in almost any type of classroom, allowing students to interact with the material in a meaningful, hands-on way. Using classroom flipping, an entire class period can be freed up for this interactive experience during which the student has access to immediate feedback from the instructor, as well as the opportunity to teach and learn from peers. We conducted an anonymous poll after this activity and found that students liked the flipped class format, but not for every lecture (data not shown), and most of them perceived that the activity helped them learn the process of protein translation (Fig. 2). While further investigation is needed, limited preliminary data suggest that the activity did not help students perform better on exam questions pertaining to transcription/translation during one semester (Appendix 3, Fig. 1). However, summative assessment data showed that the majority of students (91%) achieved the learning outcome, namely, that students will be able to translate a protein from a given piece of DNA (Appendix 3, Fig. 2). Further studies with large n values would be needed to determine whether the activity significantly increases student learning.

SUPPLEMENTAL MATERIALS

Appendix 1: Instructions sheet – student copy
Appendix 2: Instructions sheet – instructor copy
Appendix 3: Summative assessment data
Appendix 4: iClicker quiz
Appendix 5: Templates for printable magnetic pieces
Appendix 6: Flipped lecture PowerPoint slides

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REFERENCES