Understanding protein synthesis: a role-play approach in large undergraduate human anatomy and physiology classes

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Sturges D, Maurer TW, Cole O. Understanding protein synthesis: a role-play approach in large undergraduate human anatomy and physiology classes. Adv Physiol Educ 33: 103–110, 2009; doi:10.1152/advan.00004.2009.—This study investigated the effectiveness of role play in a large undergraduate science class. The targeted population consisted of 298 students enrolled in 2 sections of an undergraduate Human Anatomy and Physiology course taught by the same instructor. The section engaged in the role-play activity served as the study group, whereas the section presented with a traditional lecture served as the control group. A pretest/posttest assessment and a survey were administered to both sections and used in data analysis. In addition, overall test scores and item analysis were examined. The analysis revealed that participants in both groups improved significantly from pretest to posttest, but there were no significant differences between the groups in posttest scores. Neither group showed a significant change from posttest to the exam. However, there was a moderate positive effect on engagement and satisfaction with the survey questions from being in the study group (based on 255 exam scores). The results supported the hypothesis that role play was as effective as the lecture in terms of student performance on the above-mentioned assessments. In addition, it proved successful in engaging students in the learning process and increasing their satisfaction.

IN THE UNDERGRADUATE CURRICULUM, human anatomy and physiology courses are traditionally taught using lectures. In these, students usually assume passive roles as listeners while the instructor imparts the information. To help students become active, independent learners, instructors need to introduce active learning methods and reduce the use of passive lecture format (14). Active learning is encouraged by the American Association of Higher Education as an important component of the Seven Principles of Good Practice in Undergraduate Education (4). Strategies promoting active learning are defined as “instructional activities involving students in doing things and thinking about what they are doing” (2). They include discussions, visual-based instruction, cooperative learning, debates, drama, role playing and simulation, and peer teaching (2). Mayer (16) emphasized the importance of the cognitive component of the activity (e.g., selecting, organizing, and integrating knowledge) to promote meaningful learning. This view was supported by Chickering and Gamson (4), who accentuated that students should “talk about what they are learning and write about it.”

For the purpose of this article, active learning methods refer to a variety of classroom activities such as interactive modules, educational games, improvisations, and role play. As an example of active learning, role play was used in different disciplines such as medical education (27), accounting (13), ecological economics (35), industrial psychology (7), and managerial business education (17). Van Ments (36) defined role play as follows:

One particular type of simulation that focuses attention on the interaction of people with one another...the idea of role play is that of asking someone to imagine that they are either themselves or another person in a particular situation...they, or the class, or both, learn something about the person/situation.

McKeachie (18) defined role play as “a drama in which participants are assigned a character to portray.” Kolb and Fry (as cited in Ref. 27) argued that role play drew on experiential learning theory with learning environments of thinking, feeling, watching, and doing. Role play also gives students immediacy to academic descriptive material, provides rapid feedback, and is highly motivating (36).

Like many other science courses, physiology is one of the subjects that many students find hard to study. The first author’s student evaluations frequently include statements about the difficult nature of the course such as “Anatomy and Physiology is just a hard class,” “Information is so hard to learn,” “This subject requires a lot of preparation and effort,” and “This class is very challenging for me.” More research is needed to understand the sources of difficulty for students, since students do not specify what exactly makes this subject difficult. However, faculty members have indicated that the difficulty in studying physiology is related to the nature of the discipline, the teaching of physiology, and what students bring to the learning of physiology (21). Obviously, how we teach is important for students mastering the subject, as reflected in the National Science Education Standards (26).

The following studies have documented the use of active learning strategies in biology and human anatomy and physiology courses:

- Role play to teach protein synthesis (33), glycolysis and Krebs cycle (31), and mitosis and meiosis (5, 37);
- Improvisation in teaching muscle contraction (10, 38), the reflex arc, and capillary filtration (38);
- Games like “Survivor” for respiratory physiology (8), puzzles for gastrointestinal physiology (1), and card games for gastrointestinal physiology (28);
- Interactive study modules for hypertension (11), self-learning exercises (9), and “views from the inside” (25) for cardiovascular physiology, Pop-It beads for substrate...
and enzyme action (30), and Lego building blocks to study protein synthesis (34);
- Technology-based skits on protein synthesis and meiosis on the internet (12, 23).

Michael (19) argued that researching the effectiveness of teaching methods was essential for a research agenda in physiology. While there is evidence that some active learning methods (such as inquiry-based learning, peer collaboration, and concept mapping) are effective in physiology (20), the benefits of different approaches cannot be compared without an appropriate study design. Many studies have focused mostly on student satisfaction and reported that students enjoyed the activity (1, 8, 10, 22), liked being part of something (33), found the tool useful (8) or helpful and fun (10), and thought that the activity helped them visualize the molecular processes (31). A drawback of these studies is the fact that they did not compare these techniques with other methods of teaching. Other studies have indicated improvement on assessment scores. Wyn and Stegink (37) reported an improvement on quiz scores among study and control groups, but they targeted a small class (25 vs. 27 students, respectively). Chinnici et al. (5) found higher scores on bonus point quizzes for the group that played mitosis. Huang and Carroll (9) reported that self-learning exercises were at least as effective as the traditional lecture. Ross et al. (31) indicated from student surveys and focus group discussions that students had an enhanced ability to remember and recall the knowledge and hypothesized the creation of a mental image of a microscopic process, but did not compare the results with a traditional lecture setting.

Role play has value to students and to the improvement of the environment in which students learn (29) and could be a valuable tool for the enhancement of knowledge (15). Some studies have indicated that students might be hesitant (37) or resistant (29) to get involved mainly because they have become comfortable in their passive role (24). Others revealed a high acceptance of role play among teachers and students (35), although teachers could encounter several issues in preparation for role play. Role-play preparation required more time and effort to be successful, and instructors could face problems generating enough characters or useful resources (3).

In physiology, role plays have often been designed to help students visualize the events of a physiological mechanism (5, 10, 37, 38). In this study, role play was used to address the topic of protein synthesis. It lasted ~35–40 min and took place during one class period (50 min). Students in the class were asked to volunteer for the role play, were assigned the roles of nucleic acids and ribosomes, and were invited to become part of the protein synthesis process.

The following hypotheses were examined about the role play group compared with the lecture group:

- **Hypothesis 1.** Students in the role-play group will improve more from pretest to posttest.
- **Hypothesis 2.** Students in the role-play group will 1) perform better on exam questions pertaining to protein synthesis and 2) perform better on the exam overall.
- **Hypothesis 3.** Students in the role-play group will report higher levels of engagement in class activities.
- **Hypothesis 4.** Students in the role-play group will report higher levels of satisfaction with the learning experience.

### MATERIALS AND METHODS

The effectiveness of the protein synthesis role play was assessed in two sections of a Human Anatomy and Physiology course (the lecture component) at a large university in southeast Georgia (Georgia Southern University). This is a two-semester course (semesters I and II) without prerequisites that is required for all allied health majors. It enrolls an average of 150 students per section per semester. The target population for the study was represented by 298 students enrolled in 2 sections of the course taught by the same instructor in the fall semester of 2008. Only 31 students (21%) in each section were freshmen. Upon Institutional Review Board approval, students in one section served as the study group and learned about protein synthesis through role play, whereas the other section served as the control group and was presented with a traditional lecture. The concepts and materials presented in the lecture (control group) classroom were identical in content to those of the role-play (study group) classroom to remove potential instructor bias in the outcomes.

In the study of cytology and cellular function, protein synthesis occupies an important role. The topic is discussed in a variety of courses such as biology, molecular biology, and anatomy and physiology. However, many students in human anatomy and physiology classes are often overwhelmed by the terminology (what is a gene, base triplet, codon, and anticodon), its process (why does it happen in two steps, one in the nucleus and one in the cytoplasm), and the complex interrelationship between the nucleic acids (rRNA, mRNA, tRNA, and DNA) during transcription and translation.

### Description of the Lecture

The topic of protein synthesis is included in the lecture on the cell cycle and is covered in 14 slides. Information for the slides came from chapter 4 of the adopted classroom textbook “Anatomy and Physiology: Unity of Form and Function” by K. Saladin (32). The slides included information on the role of nucleic acids (DNA, tRNA, mRNA, and rRNA) and ribosomes, characters involved in transcription and translation and their location, and end-products of each step. Some of the pictures used during the lecture showed the structure of tRNA [Fig. 4.8 (32)], translation [Fig. 4.7 (32)], and the relationship of the DNA structure to the peptide structure [Fig. 4.10 (32)].

### Description of the Role Play

The primary goals of the role play were as follows: 1) encourage students to think about the complex interaction between nucleic acids and the sequence of DNA-RNA-polypeptide while using correct terminology; 2) reinforce the application of the law of complementary base pairing as it applies to protein synthesis; 3) provide a simplified visual and hands-on representation of molecular processes, including translation and transcription; 4) involve students as active learners in a large classroom; 5) provide a simple activity that can be easily performed within the timeframe of one class; and 6) improve students satisfaction with the learning experience.

**Transcription.** The role play requires little preparation, some space in the classroom, signs for the characters, and some props (see Table 1 for resources and characters). The role play begins with transcription. Students representing DNA form line 1 in the nucleus. Students representing mRNA form line 2 as they arrange themselves in front of line 1 according to the law of complementary base pairing.

**Role of the Instructor During This Step.** Once line 2 has been formed, a discussion ensues between the instructor and students as students are asked to verify if the arrangement is correct. Here, the instructor reads out each base triplet and codon and asks the class for verification. If students find any mistakes, the class is asked to correct them. If students do not identify any mistakes, the instructor assumes this role and corrects them. The instructor asks students to summarize the events of transcription, guiding the discussion to a review of terminology, location of the event, and end-products.
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EFFECTIVENESS OF ROLE PLAY

How We Teach

Table 1. Resources and characters for the role play

<table>
<thead>
<tr>
<th>Resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class time of at least 50 min</td>
</tr>
<tr>
<td>Clear space in the front of the classroom for ease of movement</td>
</tr>
<tr>
<td>Props</td>
</tr>
<tr>
<td>Stage, rope, or chalk to form a circle representing the nucleus</td>
</tr>
<tr>
<td>Participants</td>
</tr>
<tr>
<td>33 students to play the roles of different nucleic acids*</td>
</tr>
<tr>
<td>2 students to play the role of the ribosome</td>
</tr>
<tr>
<td>Laminated cards with a large font (36 cards in total*)</td>
</tr>
<tr>
<td>Yellow cards for 11 base triplets on DNA</td>
</tr>
<tr>
<td>Purple cards for 11 codons on mRNA</td>
</tr>
</tbody>
</table>
| Green cards for 11 codons on tRNA on one side and the corresponding amino acid on the other

<table>
<thead>
<tr>
<th>Characters</th>
</tr>
</thead>
<tbody>
<tr>
<td>The nucleus, represented by a circle using rope, chalk, or a stage at the front of the classroom</td>
</tr>
<tr>
<td>One DNA strand, composed of 11 students, each holding a yellow laminated card with a base triplet on it, in the nucleus, facing the classroom</td>
</tr>
<tr>
<td>One mRNA strand, composed of 11 students, each holding a purple laminated card with a codon on it, in the nucleus, facing the classroom</td>
</tr>
<tr>
<td>The ribosome, represented by 2 students facing each other in the cytoplasm (i.e., the classroom)</td>
</tr>
<tr>
<td>One polypeptide strand, composed of 11 students, each holding a green laminated card with tRNA anticodons on one side and amino acids on the other</td>
</tr>
</tbody>
</table>

*Numbers can be adjusted by the instructor depending on the space and time available as well as the number of students that the instructor wants to involve.

Translation. In translation, students representing mRNA pass through the ribosome, as students representing tRNA carrying the anticodon are pairing with the codon forming a parallel line to mRNA. Students representing tRNA then turn over their cards, which have the names of the amino acids.

ROLE OF INSTRUCTOR DURING THIS STEP. The instructor can make an arrangement in which the first student representing mRNA passing through the ribosome carries a start codon, whereas the last one carries a stop codon. The instructor then asks students to summarize the events of translation, guiding the discussion to a review of terminology, location of the event, and end-products.

Methods

Before discussing the topic, students in both sections were asked to answer a seven-question multiple-choice quiz (pretest) on protein synthesis using the assessment instrument shown in Table 2. These questions were selected from the manufacturer’s (McGraw-Hill) test bank and assessed students’ knowledge of different aspects of protein synthesis, such as the role of nucleic acids, end-products of translation, and the law of complementary base pairing. Students were not allowed to use their notes or textbooks to answer the questions. After the pretest assessment, the study group was involved in the role play, whereas the control group was presented with the lecture. At the end of the class period, students were asked to answer the same quiz (posttest) using the assessment instrument shown in Table 2. Students were not provided with the correct answers at the end of the posttest assessment. Scores for both assessments were recorded using the Classroom Performance System (CPS),1 and students were identified using their remote identification number for confidentiality purposes. These scores did not affect the students’ final grade, since they were not part of the graded assignments scheduled for the class. Within 1 wk, students answered the same questions (Table 2) that were incorporated into test 1. Exam scores for the whole test as well as responses to the individual questions were used to assess the long-term learning outcomes in both sections. To ensure confidentiality, during analysis, names were removed and students were identified using the identification numbers on the CPS remotes.

Students in both sections were also asked to complete an additional survey that evaluated their perceptions on the effects of the role play (for the study group) or lecture (for the control group) on their understanding of the topic, classroom engagement, and satisfaction (see Table 3). The survey consisted of 32 questions and included 7 demographic questions, 11 understanding questions, 7 engagement questions, and 7 satisfaction questions. Participation in the survey was voluntary and anonymous, and data were collected using the CPS in “anonymous” mode.2 To increase the response rate, students were offered extra credit points. However, the same point value was given to all students present in the class regardless of their participation in the survey, and attendance was recorded separately using the CPS.

Plan of Analyses

To evaluate the four project hypotheses, the data analysis is presented in three stages. First, multivariate demographic analyses explored preexisting similarities and differences between the control and study groups. Second, multivariate analyses of the pretest, posttest, and study groups. Second, multivariate analyses of the pretest, posttest assessment and exam questions

Table 2. Pretest/posttest assessment and exam questions

1. The sequence of three DNA nucleotides that determines one amino acid is ___.
   A. an anticodon
   B. a gene
   C. a base triplet
   D. a codon

2. The RNA that carries the amino acids to the ribosome is ___.
   A. mRNA
   B. tRNA
   C. rRNA
   D. All of the above

3. Where would you find an anticodon?
   A. on mRNA
   B. on a ribosome
   C. on tRNA
   D. on DNA

4. What reads the codons on mRNA and binds to the appropriate tRNA?
   A. Ribosomal subunit
   B. Golgi complex
   C. Nucleolus
   D. DNA

5. If DNA has a sequence of ATTCGGCAA, then a segment of mRNA synthesized from it will have a sequence of ___.
   A. TAAAGCGGT
   B. GUUCAAGTT
   C. UAAAGCGUU
   D. UAAAGCCTTT

6. mRNA is synthesized in the ___.
   A. plasma membrane
   B. endoplasmic reticulum
   C. ribosome
   D. nucleus

7. The end product of translation is ___.
   A. DNA
   B. rRNA
   C. pre-mRNA
   D. a polypeptide

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1 CPS is a computer performance system that uses remotes (clickers) for test and quiz taking in the classroom.

2 CPS has an anonymous mode that, if checked, collects the responses in aggregate form.
Table 3. Student demographics, understanding, engagement, and satisfaction survey

I. Demographics

1. What is your gender?
   A. Male
   B. Female
2. What is your major/premajor?
   A. Nursing
   B. Athletic training
   C. Exercise Science
   D. Nutrition
   E. Community Health
   F. Biology/Premed
   G. Other
3. Is this course required for your major?
   A. Yes
   B. No
4. Your pre-AP grade point average was within which of the following ranges:
   A. <2.0
   B. 2.1–2.5
   C. 2.6–3.0
   D. 3.1–3.5
   E. >3.5
5. What grade did you expect on test 1 in this class?
   A. A (90–100%)
   B. B (80–89%)
   C. C (70–79%)
   D. D (60–69%)
   E. F (59% and less)

II. Survey

Indicate your opinion about the following statements using this response scale:
1 = strongly disagree
2 = disagree
3 = neither agree or disagree
4 = agree
5 = strongly agree

Understanding
8. The activity clearly identified major points in protein synthesis.  
9. The activity increased my understanding of the role of mRNA in protein synthesis.  
10. The activity increased my understanding of the role of tRNA in protein synthesis.  
11. The activity increased my understanding of the role of DNA in protein synthesis.  
12. The activity increased my understanding of the role of the ribosome in protein synthesis.  
13. The activity increased my understanding of transcription.  
14. The activity increased my understanding of translation.  
15. The activity helped me to visualize the process of protein synthesis.  
16. The interactive nature of the activity facilitated my learning of the content area.  
17. The activity helped me organize my notes in preparation for this test.  
18. Overall, the activity helped me to understand protein synthesis better.

Engagement
19. The activity offered more opportunities for participation than a regular AP lecture.  
20. The number of participants was appropriate.  
21. The activity encouraged student interactions.  
22. The activity promoted discussion of key topics.  
23. Playing the activity was an effective use of time.  
24. The activity was an appropriate way to engage students.  
25. Overall, the activity was engaging.
test, and exam assessments explored differential improvement between the groups over time. Third, multivariate analyses of self-reported understanding, engagement, and satisfaction explored differences in students’ postlearning reflections on the process.

RESULTS

Demographic Analyses

Demographic data for the control and study groups are shown in Table 4. To assess potential differences between students in the two groups, multivariate ANOVA was conducted with all six demographic questions as dependent variables and group membership (control/study) as the independent variable. A significant multivariate effect emerged for group membership (Pillai’s trace \( \eta^2 = 0.06 \), \( F_{6,247} = 2.42, P < 0.001 \), partial \( \eta^2 = 0.06 \)). Followup univariate ANOVAs for all six dependent variables revealed two significant models: major (\( F_{1,252} = 4.79, P < 0.05 \), and partial \( \eta^2 = 0.02 \)); and expected grade on the first test (\( F_{1,252} = 8.08, P < 0.01 \), and partial \( \eta^2 = 0.03 \)). Because group membership was the only independent variable, univariate model statistics were identical to group membership statistics within the model and can be interpreted as such. Thus, the only preexisting differences between the groups were a slightly higher percentage of nursing majors in the study group than in the control group and a slightly higher expected grade on the first test in the control group than in the study group. Both of these differences were statistically quite small (6) and suggested that preexisting differences between the two groups were unlikely to bias other results.

Pretest/Posttest Assessments and Exam Scores

Two (group) x three (time) repeated-measures multivariate ANOVA revealed a significant multivariate main effect for time (Pillai’s trace = 0.70, \( F_{2,235} = 270.17, P < 0.001 \), and partial \( \eta^2 = 0.70 \)) and a group x time interaction (Pillai’s trace = 0.41, \( F_{2,235} = 41.23, P < 0.001 \), and partial \( \eta^2 = 0.41 \)).

Table 4. Demographic variables by group

<table>
<thead>
<tr>
<th></th>
<th>Control Group</th>
<th></th>
<th>Study Group</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Number of students</td>
<td>%</td>
<td>Number of students</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>129</td>
<td></td>
<td></td>
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<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>35</td>
<td>27.8</td>
<td>24</td>
<td>18.6</td>
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<tr>
<td>Female</td>
<td>91</td>
<td>72.2</td>
<td>105</td>
<td>81.4</td>
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<tr>
<td>Major</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nursing</td>
<td>47</td>
<td>37.3</td>
<td>68</td>
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<td>Health and Kinesiology</td>
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<td>34.9</td>
<td>37</td>
<td>28.7</td>
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<tr>
<td>Biology/ Premed</td>
<td>12</td>
<td>9.5</td>
<td>8</td>
<td>6.2</td>
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<tr>
<td>Other</td>
<td>23</td>
<td>18.3</td>
<td>16</td>
<td>12.4</td>
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<tr>
<td>Required course</td>
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<td></td>
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<tr>
<td>Yes</td>
<td>111</td>
<td>88.1</td>
<td>119</td>
<td>93.0</td>
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<tr>
<td>No</td>
<td>15</td>
<td>11.9</td>
<td>9</td>
<td>7.0</td>
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<tr>
<td>Self-reported grade point average</td>
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<td></td>
</tr>
<tr>
<td>&lt; 2.0</td>
<td>4</td>
<td>3.2</td>
<td>4</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>2.1–2.5</td>
<td>21</td>
<td>16.7</td>
<td>21</td>
<td>16.3</td>
<td></td>
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<tr>
<td>2.6–3.0</td>
<td>28</td>
<td>22.2</td>
<td>32</td>
<td>24.8</td>
<td></td>
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<tr>
<td>3.1–3.5</td>
<td>48</td>
<td>38.1</td>
<td>48</td>
<td>37.2</td>
<td></td>
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<tr>
<td>&gt; 3.5</td>
<td>25</td>
<td>19.8</td>
<td>24</td>
<td>18.6</td>
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<tr>
<td>Expected grade on test 1</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>A (90–100%)</td>
<td>55</td>
<td>43.7</td>
<td>30</td>
<td>23.3</td>
<td></td>
</tr>
<tr>
<td>B (80–89%)</td>
<td>47</td>
<td>37.3</td>
<td>63</td>
<td>48.8</td>
<td></td>
</tr>
<tr>
<td>C (70–79%)</td>
<td>20</td>
<td>15.9</td>
<td>30</td>
<td>23.3</td>
<td></td>
</tr>
<tr>
<td>D (60–69%)</td>
<td>2</td>
<td>1.6</td>
<td>2</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>F (&lt; 59%)</td>
<td>2</td>
<td>1.6</td>
<td>4</td>
<td>3.1</td>
<td></td>
</tr>
<tr>
<td>Prior knowledge of protein synthesis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never heard of it before</td>
<td>13</td>
<td>10.3</td>
<td>8</td>
<td>6.2</td>
<td></td>
</tr>
<tr>
<td>Heard of it but did not know what it was</td>
<td>32</td>
<td>25.4</td>
<td>48</td>
<td>37.2</td>
<td></td>
</tr>
<tr>
<td>Somewhat knew what it was but could not explain it well</td>
<td>72</td>
<td>57.1</td>
<td>69</td>
<td>53.5</td>
<td></td>
</tr>
<tr>
<td>Knew what it was and could explain it well</td>
<td>9</td>
<td>7.1</td>
<td>4</td>
<td>3.1</td>
<td></td>
</tr>
</tbody>
</table>

Grade point average data were not verified against institutional records. *P < 0.05; †P < 0.01.
0.05, $F_{2.235} = 5.74, P < 0.01$, and partial $\eta^2 = 0.05$). Followup analyses of within-subjects effects confirmed the effects for both time ($F_{2.472} = 292.21, P < 0.001$, and partial $\eta^2 = 0.55$) and the group $\times$ time interaction ($F_{2.472} = 6.03, P < 0.01$, and partial $\eta^2 = 0.03$). No main effects were observed for group [$F_{1.236} = 0.01$, not significant (NS)].

To explore the group $\times$ time interaction, additional comparisons of means were conducted. Significant improvement from pretest to posttest was observed for both the control ($t_{118} = -12.92, P < 0.001$, Cohen’s $d = 1.33$) and study ($t_{118} = -18.13, P < 0.001$, and Cohen’s $d = 2.12$) groups, although the net learning gains were greater for the study group. No additional improvement was observed from posttest to exam for either the control ($t_{118} = 0.06$, NS) or study ($t_{118} = 0.71$, NS) groups. A significant difference between groups appeared at pretest ($t_{236} = 2.43, P < 0.05$, and Cohen’s $d = 0.32$) but not at either posttest ($t_{236} = -1.44$, NS) or exam ($t_{236} = -0.89$, NS). Thus, it appears the group $\times$ time interaction was driven by a preexisting difference between groups that leveled out by posttest (see Table 5).

Survey

Of the 298 students enrolled in the 2 sections, a total of 255 students returned the student survey (response rate: 86%); 129 students were in the study group and 126 students were in the control group. Among the total participants, 59 (23.1%) students were male and 196 (76.9%) students were female. Students represented different majors with a total of 115 (45.1%) students in the Nursing major, 81 (31.8%) students in the Health and Kinesiology majors, 20 (7.8%) students in the Biology/Premed major, and 39 (15.3%) students in other majors. In terms of previous experience with protein synthesis, 21 (8.2%) students never heard of it before, 80 (31.4%) students had heard of it before but did not know what it was, 141 (55.3%) students somewhat knew what it was but could not explain well, and only 13 (5.1%) students knew what it was and could explain it well. While the two groups were not identical, they were similar enough in terms of gender, major, course required or not, self-reported grade point average, expected grade on test 1, and participants’ previous experience with protein synthesis to make comparisons meaningful (see Table 4).

To explore hypotheses 3 and 4, three scales were created from student survey questions 8–32: understanding (11 items, Chronbach’s $\alpha = 0.92$), engagement (7 items, Chronbach’s $\alpha = 0.91$), and satisfaction (7 items, Chronbach’s $\alpha = 0.95$). Multivariate ANOVA with group membership as the independent variable was then conducted for the three scales. A significant multivariate main effect for group emerged (Pillai’s trace $= 0.28$, $F_{3,242} = 31.62, P < .001$, and partial $\eta^2 = 0.28$). Followup univariate ANOVAs revealed significant models for all three scales, all of which were significantly influenced by group membership. Participants in the study group reported higher scores than those in the control group (see Table 5).

DISCUSSION

This study sought to investigate the effectiveness of role play in teaching and learning protein synthesis. The purpose of this research was unique in that it:

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<th>Measures and Questions</th>
<th>Control Group</th>
<th>Study Group</th>
<th>$F_{1.244}$</th>
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*P < 0.05; †P < 0.001.
EFFECTIVENESS OF ROLE PLAY

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How We Teach

- Targeted a large, undergraduate Human Anatomy and Physiology class (~150 students/section)
- Targeted mostly allied health majors (Nursing, Health and Kinesiology, Biology, and others)
- Assessed the effectiveness of role play compared with a traditional lecture setting
- Complemented a self-reported survey with assessment scores on pretest/posttest/exam and researched student learning
- Had a study design with two comparable groups based on demographic characteristics.

Previous studies had small classes (5, 7, 37, 38), did not research student learning primarily (37), had no pretest assessment and discussion on how comparable the two groups were (5, 7) or had no study and control groups (8), targeted mostly Biology or nonmedical majors (5, 7, 17, 22, 37), did not research role play (8, 9, 11, 13, 22, 25), presented no evaluation of effectiveness (3, 10, 33), and did not combine a self-reported survey with assessment scores (5, 8, 28, 31, 35, 37).

In this study, student learning was assessed immediately after the classroom experience (role play for the study group and lecture for the control group) and 1 wk later to test hypotheses 1 and 2. Assessment supported hypothesis 1: that students in the study group would improve more from pretest to posttest. This analysis showed greater gains on post-test assessment for the study group, although participants in both groups improved significantly from pretest to posttest. The study group did reveal lower initial scores on the pretest assessment, and it is possible that if the two groups had the same initial scores, we would have seen a larger difference at posttest.

Neither group showed a significant change from posttest to the exam, failing to support hypothesis 2 and previous findings (5, 13, 37). However, when these results were compared with the “understanding” answers on the survey (questions 15, 16, and 18), the study group reported a higher positive effect. These results seem to suggest that students in this group perceived that they learned more through role play. It is worth mentioning that students in the study group also reported that the role play helped them to visualize the process of protein synthesis (question 15), supporting a previous study (31) showing that role play creates a mental picture of molecular or submicroscopic process and helps students link macroscopic with microscopic levels. This can be further enhanced by supplementing the role-play activity with a diagram that students can fill out to help with organization of concepts.

Hypothesis 3, that students would become more engaged in class activities, was fully supported. Students in the study group unanimously agreed that the role play engaged them in classroom activities, offered more opportunities for participation that a traditional lecture, encouraged student interactions, and was an appropriate way to engage students. These findings supplement previous studies (5, 31, 33, 37) on role play in physiology that did not examine student engagement.

Hypothesis 4, that students would be more satisfied with the learning experience, was supported. Students in the study group indicated a large positive effect on satisfaction. They found the role play interesting, stimulating, fun, and educationally attractive due to novelty of the style. These findings support previous research on active approaches from biology and physiology studies (1, 8, 10) and role play in particular (38) and extend the findings from previous studies (5, 13, 37) on role play that did not examine student satisfaction. This analysis indicated that students would recommend the development of similar activities for other content areas, proving a high role-play acceptance (35) and disproving the existence of resistance to the introduction of active learning techniques (29).

The results did not show that the more active environment enhanced student performance, although the study group showed larger gains from pretest to posttest. It seems that the role-play environment did not offer much advantage over the lecture format in regard to student performance; however, role play was at least as effective as the lecture. The role play clearly offered advantages over the lecture in terms of student involvement and satisfaction. It provided students in a large classroom the opportunity to interact with the instructor and their colleagues. The instructor guided the role play and some students “played” the role of nucleic acids (physical involvement), and everybody had a chance to participate in the discussion (cognitive involvement). This was reflected in the higher satisfaction scores within the study group. As such, this simple activity can be useful to those who would like to complement lectures with activities that engage students within regular class time and give the instructor the ability to generate as many characters as desired (3). For example, our activity included 35 students playing the role of base triplets, codons, anticodons, and ribosomes. The number of students involved can be decreased or increased depending on the available space in the classroom and/or time.

This role play on protein synthesis is easy to use in the classroom, can be enacted in a large class within a typical class period, and does not require significant preparation time. Based on our results, it also shows promise as a technique that enhances student engagement in the classroom and satisfaction with the learning environment and is as effective as the lecture in terms of student performance. We are currently using the role play every semester in our classes, and we recommend its use in undergraduate courses in conjunction with lecture. Our future endeavors include the design of similar activities for other topics (such as the hypothalamic-hypophyseal relationship) and comparison of the effectiveness of role play for different topics.

REFERENCES

How We Teach


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