Efficacy of Role Play in Concert with Lecture to Enhance Student Learning of Immunology

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Despite numerous reports that active learning increases student understanding, many barriers still exist that prevent faculty from shedding the traditional passive lecture and adopting active learning strategies in the classroom. This study looks at the use of role play as an active learning technique to convey new material, or as reinforcement to traditional lecture. A pre- and post-test survey was utilized to determine student learning gains, along with an anonymous survey to determine student attitudes about role play. Student learning gains are similar regardless of class size, role-playing participation or learning style, and reflect an increase in lower order cognition. Attitudes and learning gains indicate role play is preferable as a reinforcement technique, although the order does not matter if both lecture and role play are utilized to convey information. These data provide insight into the best practices of role-playing implementation in concert with traditional lecture format.

INTRODUCTION

Active learning techniques have been widely shown to increase student interest, understanding and retention (reviewed in (5)). Role play is a particularly robust active learning technique that is widely used in higher education. There are many types of role play including simulation (debates, court cases), games, metaphorical role play (where students portray a specific object such as a biological molecule), and presentations (where students adopt a role or produce commentary) (12). Simulation role play is often used in the humanities and social sciences to bring historical events to life, create mock business environments and spark ethical debates (1, 8, 11). Metaphorical role play, where students portray specific parts of a process and interact with each other, has been particularly adopted in the sciences to visualize abstract concepts such as respiration, photosynthesis and cell division (3, 6, 9, 14). While a few of these studies show that role play imparts greater learning gains than traditional lecture, most reports are anecdotal or lack detailed assessment.

Despite data that active learning promotes greater student understanding of course material, many barriers still exist that prevent instructors from adopting active learning strategies, including perceptions about preparation time, reduced confidence in teaching via a new method, and in-class time investment (5, 10, 13). Instructors that do use techniques like role play often intersperse these activities with traditional lectures in the classroom. However, most research addresses the effect of role play in one class section compared to traditional lecture in a separate class section. This does not address the efficacy of role play in concert with the traditional lecture classroom.

In this study, a detailed assessment of learning gains of students who use role play in the classroom to learn the basics of an immune response was conducted. The efficacy of role play in classrooms of different sizes, where all students or only a subset of students perform the activity, is addressed. The learning gains of students in relation to participation in the role play, learning styles, and order of initial presentation and reinforcement of concepts are investigated. Student attitudes about the experience to gain insight into their learning experience are investigated. These data provide information on the practical use of role play in the classroom, and highlight the best practices for implementation of role play to maximize student learning.

MATERIALS & METHODS

Course information

All courses involved in this study were offered at St. Mary’s College of Maryland by the same instructor from 2007-2009. Introductory Biology (BIOL105) initially enrolls 85 students in each section, consisting primarily of first year students who intend to major in Biology or Biochemistry, or students of other majors who intend to apply to medical school. Immunology (BIOL470) is an upper-level course for junior and senior Biology majors with a maximum enrollment of 24.

Role play to demonstrate the mechanics of an immune response

Students in this study voluntarily participated in a role play exercise where they acted as cells of the immune response and used props to simulate pathogens, receptor
interactions to induce cellular activation, and effector responses. A similar role play to the one used in this study has been previously published (4). Students were assigned roles on the day of role play, and no background preparation was expected. The instructor narrated the sequence of events, with students following their roles and predicting immune cell activation by color-coded receptor interactions. Immune responses to both intracellular viral and extracellular bacterial pathogens were portrayed.

Pre- and post-test administration

All study materials and consent procedures were approved by the Institutional Review Board at St. Mary’s College of Maryland. During Fall 2007, BIOL105 and BIOL470 were given a pre- and post-test of 10 multiple-choice questions from the role play that required recall of basic knowledge. The pre-test was given immediately before the role play, while the post-test was given immediately after the role play on the same day. The questions on the pre- and post-test were identical, and categorization of all pre- and post-test questions was determined using the Blooming Biology Tool (BBT) (7). In BIOL470, all students participated in the role play, while in BIOL105 a subset of students demonstrated the role play while their peers observed the activity. During Fall 2008, BIOL470 followed these same procedures for data collection.

To ascertain the efficacy of lecture compared to role play, the two sections of BIOL105 were initially exposed to either lecture or role play during the Fall 2008 and 2009 semesters. On the first day, a pre-test of 16 multiple-choice questions was given that required recall of basic knowledge (10 questions) or application of knowledge of new situations (5 questions) based upon the BBT. An additional multiple-choice question addressed student use of the textbook or class notes. Each section then either experienced role play or lecture that covered the same content. Post-test 1 was given directly after lecture or role play on the same day. During the next class period, the content was reinforced by the alternative teaching method: the section that first experienced lecture did the role play, and the section that experienced role play listened to lecture. Post-test 2 was given immediately after the reinforcement method. Questions on the pre- and post-tests were identical.

Student attitudes and learning styles surveys

At the beginning of the semester, students in BIOL105 during the Fall 2008 and 2009 semesters were given an assignment to determine their learning style using the VARK learning styles questionnaire version 7.0 (http://www.vark-learn.com/). Scores from multimodal students were placed into their relevant categories; for example, the score of a student who learned equally well using read/write and aural techniques (multimodal (AR)) was placed in both the aural and read/write categories. Student attitudes about their learning gains were determined by an anonymous survey given immediately after post-test 2.

Statistical analyses

All data were analyzed and graphed using Prism software version 5.0.1 (GraphPad Software Inc, La Jolla, CA). All two-way repeated measures ANOVA analyses used Bonferroni post hoc tests to determine significance.

RESULTS

Role play is equally effective as a whole class activity or an in-class demonstration

To determine whether role play can be an effective learning tool in both large and small classrooms, a comparison of learning gains was conducted between two small upper-level Immunology classes where all students participated in the role play and two large introductory biology classes where a subset of students demonstrated the role play for their peers. Upper-level students scored one question higher on the pre-test compared to introductory students (Fig. 1, t-test, \( p = 0.005 \)). However, both classes showed equal gains in learning after the post-test, with no difference between the two classes detected (Fig. 1, t-test, \( p = 0.85 \)). This indicates that student learning gains are equivalent whether the role play is conducted with participation of the entire class or with a subset of students participating while their peers observe.

Role play may be more effectively used as a reinforcement technique rather than as a lecture replacement

To determine whether role play is better utilized as a replacement for lecture to introduce new material or as a reinforcement technique, student learning gains were measured in two sections of an introductory biology course. No significant difference was seen in the pre-test scores of both groups. Both methods show significant learning gains.

![Figure 1](image-url)
after the first post-test; however, students who experienced lecture scored significantly higher compared to students who experienced role play (Fig. 2, ANOVA, \( p < 0.05 \)). This equates to an average score of one question higher for students who experienced lecture on the first day. In the second class period of the module, each section experienced the opposite method as reinforcement of the material. Both methods of reinforcement resulted in significantly higher scores on post-test 2 as compared to post-test 1 (Fig. 2, ANOVA \( p < 0.05 \)). After this reinforcement, both groups scored equivalently on the second post-test. No significant differences in scores were seen regardless whether or not students indicated reading the book and/or their notes before taking the pre- or post-tests (data not shown). Also, retention on the corresponding exam was equivalent for both sections (data not shown). Students were surveyed about their opinions of the role play after the second post-test. While responses to the role play were overwhelmingly favorable in both sections, the majority of students preferred to experience lecture first and use role play for reinforcement of the material (Fig. 3). These data indicate that while significant learning gains can occur with either method, student attitudes and learning gains illustrate a preference for this active learning demonstration as a reinforcement method rather than a lecture replacement.

Students in larger classes show equivalent learning gains whether they observe or participate in a role play demonstration

To determine whether participation in the role-playing demonstration confers higher scores compared to students who watch their peers, an analysis of the score of role-playing participants was performed. No significant differences were seen in the scores of participants as compared to their peers at any stage of the analysis: pre-test, post-test 1 or post-test 2 (Fig. 4, ANOVA, \( p > 0.05 \)). This was true for students who experienced lecture first (Fig. 4(A)), and those who participated in role play first (Fig. 4(B)). These data indicate that equal learning gains are accomplished whether students observe or participate in the role play. This is seen if role play is used to impart new information, or if role play is used to reinforce lecture.
Learning gains are primarily in questions that address lower order cognitive thinking

An analysis of the types of questions on the surveys was conducted to ascertain whether learning gains could be attributed specifically to lower order cognitive thinking (basic recall of knowledge) or higher order cognitive thinking (application of knowledge to new situations). Significant learning gains were seen between pre- and post-tests for both types of questions (Fig. 5, ANOVA, \( p < 0.05 \)). However, greater learning gains were seen in questions that addressed basic recall (Fig. 5(A)) than questions that addressed application of knowledge (Fig. 5(B)). More students answered questions that used higher order cognitive thinking correctly on the pre-test compared to basic knowledge. This indicates that the students surveyed had previous knowledge of general concepts about immune responses, but did not understand the specifics of how these responses occurred.

Learning gains are independent of student learning styles

Introductory biology students were also surveyed on their preferred learning styles (Fig. 6(A)). The majority of students self-reported learning best by more than one method (multimodal, 39%). These students were separated into their relevant learning preferences for analysis. The most popular learning method was kinesthetic, or learning by hands-on methodology. The lowest single category was visual learners. Students who did not report learning preferences are labeled as unknown. The learning styles of students who voluntarily participated in the role play are shown in Fig. 6(B). The demographics of participants are similar to those of the whole class. Traditional lecture addresses elements of aural, visual and read/write learning styles, while role play encompasses kinesthetic, aural and visual learning. The effectiveness of the role play was examined in relation to the learning styles preferences of the participants. No significant differences were seen in the pre-tests of students with different learning styles, whether they experienced role play or lecture first (Fig. 7). As reflected in the overall data (Fig. 2), all students who experienced role play first scored significantly lower on basic knowledge recall compared to students who experienced lecture first. No other differences were seen.

DISCUSSION

Previous research shows that role play imparts greater learning gains when compared to other classes that receive lecture (3, 6, 11). However, other researchers show no significant impact on learning gains in classes that use role
play instead of lecture (8). This type of experimental design was not possible in our study due to the structure of the BIOL105 sequence, where grades between the classes are pooled for final grade calculations. We used this to our advantage to address the use of both lecture and role play to impart learning gains, which is more in line with typical classroom use of these types of active learning techniques. While these data show that lecture can impart greater learning gains than role play in the introduction of new material, student attitudes about role play as an active learning technique should not be easily dismissed. Use of active learning in the classroom produces positive student attitudes about the material being taught (2), and many students in this study specifically asked for more role-playing exercises in their course evaluations (data not shown). Increased student engagement with the material by using active learning may be worth the slight difference in learning gains if the instructor must choose only one method with no reinforcement.

No major differences between role play and lecture were seen in students with different learning styles (Fig. 7). This was surprising, as role play in particular promotes learning of kinesthetic learners, which is often not addressed by other teaching techniques. A few potential reasons exist for this finding. First, the majority of the students were multimodal learners and, as such, can take advantage of multiple teaching techniques. Traditional lecture promotes elements of visual, aural and read/write learning, while the role play does the same for students who observe their peers. Role-playing participants use kinesthetic, aural and visual learning. Secondly, student volunteers for role play encompassed a similar distribution of learning styles to those of the whole class (Fig. 6). When learning styles are known, it may be more beneficial to student learning if participants are chosen based upon kinesthetic learning style, rather than random volunteers.

In this study, the role play was scripted with no previous student preparation required. Barriers to the adoption of active learning in the classroom include the perceived loss of instructor control and the logistics of applying active learning techniques to large classes (13). This scripted method may be preferable by instructors who are recently adopting role play in their classrooms because it provides the instructor with more control over the outcome of the role play. As no differences in learning were seen between classes of different sizes (Fig. 1) or between viewers and participants (Fig. 4), the use of role play as demonstration may also be more accessible to instructors with large class sizes.

The role play in this study is only one approach to using role play in the classroom, and many modifications of this method can be made depending upon the goals of...
the instructor. In this study, role play was used in the same way a lecture, to portray the basic information of how an immune response works. Because the context of the role play was kept to a basic level, the gains in lower order cognitive thinking seen in Fig. 5(A) are a logical outcome. Also, with fewer questions that addressed higher order cognitive thinking and the greater number of correct answers on the pre-test (Fig. 5(B)), it was difficult to judge the higher order cognitive learning gains in this study. To increase higher order cognitive skills, student roles could be assigned before class to promote peer instruction opportunities, and allow more detailed discussion of cellular interactions. Application of the basic immune response to specific pathogenic infections, such as HIV, could also be portrayed by students using role play.

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