Student-Produced Video of Role-Plays on Topics in Cell Biology and Biochemistry: a Novel Undergraduate Group Work Exercise

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Introduction

Group work or cooperative learning is a form of active learning that has potential benefits that extend beyond just being an alternative or improved way of learning course material. For example, Shimazoe and Aldrich (2010) identified six proposed benefits of active learning to students, namely (1) promoting deep learning, (2) helping students earn higher grades, (3) teaching social skills & civic values, (4) teaching higher order thinking skills, (5) promoting personal growth and (6) developing positive attitudes toward autonomous learning. There is evidence for the effectiveness of role-plays both in achieving learning outcomes (Azman, Musa, & Mydin, 2018; Craciun, 2010; Latif, Mumtaz, Mumtaz, & Hussain, 2018; McSharry & Jones, 2000; Yang, Kim, & Noh, 2010), but also in developing desirable graduate attributes such as teamwork, communication and problem solving skills [4]. The importance of such skills is widely touted by employers of science graduates, sometimes more so than discipline-specific knowledge, arguing in favour of the incorporation of role-plays and other forms of cooperative learning into undergraduate science curricula.

Role-playing is probably not as widely used in the physical and life sciences as it is in other academic disciplines. In science the most obvious role-play scenarios in which students play the roles of people might be in examining historical figures at the centre of famous scientific discoveries or debates (Odegaard, 2003). In addition, role-plays fit well at the interface between science and other discipline when exploring ethical, legal or commercial implications of scientific discoveries(Chuck, 2011). However, to apply role-play to core topics in science or mathematics the roles that must be played are not those of people but rather of things like particles, forces, elements, atoms, numbers, laws, equations, molecules, cells, organs and so on. The learning scenarios for science-based role-plays in which the characters represented are not people are less obvious, probably explaining why the use of role-plays in science education is less common. Nevertheless, focusing on the life sciences, role-plays in which the characters are organelles in a cell or enzymes involved in fundamental cellular processes like DNA replication, RNA transcription and protein translation have been described for example (Cherif, Siuda, Dianne M. Jedlicka, & Movahedzadeh, 2016; Takemura & Kurabayashi, 2014).

The communication of discipline-specific templates and successful models for the application of role-playing in science education is likely to encourage their wider adoption. Here I describe a videoed group role-play assignment that has been developed over a ten-year period of reflective

teaching practice. I suggest that this model of videoed group role-plays is a useful cooperative learning format that will allow learners to apply their varied creativity and talents to exploring and explaining diverse scientific topics while simultaneously developing their teamwork skills.

Method

The context of this case study is a 3rd year undergraduate course entitled *Introduction to Cell Biology and Biomembranes (BC3003)*. In the 2018/2019 academic year thirty nine Irish BSc Biochemistry students and seven visiting international students were registered for the course. The group role-play assignment described here is a continuous assessment element, accounting for 7% of the overall module marks.

The role-plays focus on topics related to the cytoskeleton, protein targeting and vesicular trafficking. Groups of 7-8 students are assigned a specific cellular process and each group member is cast by the instructor as a protein or protein complex involved in that process. Each group member researches their own protein/protein complex and posts a short description of its function to a group discussion board. The groups then meet outside of regular class hours to develop and rehearse a role-play based on their assigned cellular process. Groups then produce a video of their role-play rather than having them perform it live in front of the class. The role-plays are uploaded to the YouTube video hosting service as unlisted videos, providing a simple way to share videos with the entire class. Written consent was obtained from students to use the videos in this manner.

The grading of group-work assignments is fraught with difficulty (King & Behnke, 2005). It is generally desirable to assign individual marks to members of a group in a manner that rewards those who contribute most to the project. A simple but fair peer assessment system was developed that involves students distributing twelve votes among the seven or eight members of their group simply according to their impression of the contribution that they made to the project. The rules of the voting system aim to ensure that students do discriminate to some extent between group members in terms of their contribution, while at the same time mitigating against reciprocal voting pacts.

Findings

Student groups were given a large degree of freedom to develop the concept for their role-play as they saw fit. The only stipulations were that all of the "characters" must be involved and that the role-play would accurately illustrate the assigned cellular process. It is not surprising then that the six groups developed very different styles of role-plays with unique concepts to represent their cellular processes. McSharry and Jones (McSharry & Jones, 2000) identified seven overlapping categories of role-plays in the context of science teaching and learning. According to this classification the role-plays developed here fall into the categories of presentations and analogy role-plays. Two groups used animation or drawing rather than physically acting out the role-play (Figure 1), with each group member then describing the role played by their protein in the cellular process using voice-over. Two groups described their assigned cellular processes using narrated demonstrations in which students acted out their roles in the process with the aid of simple props like balloons, foam noodles, coats, back packs, rope. Finally, two groups performed dramatized role-plays, making quite extensive

analogies between the proteins/protein complexes/subcellular locations involved in their assigned process and the characters/locations in their role-play (Table 1).

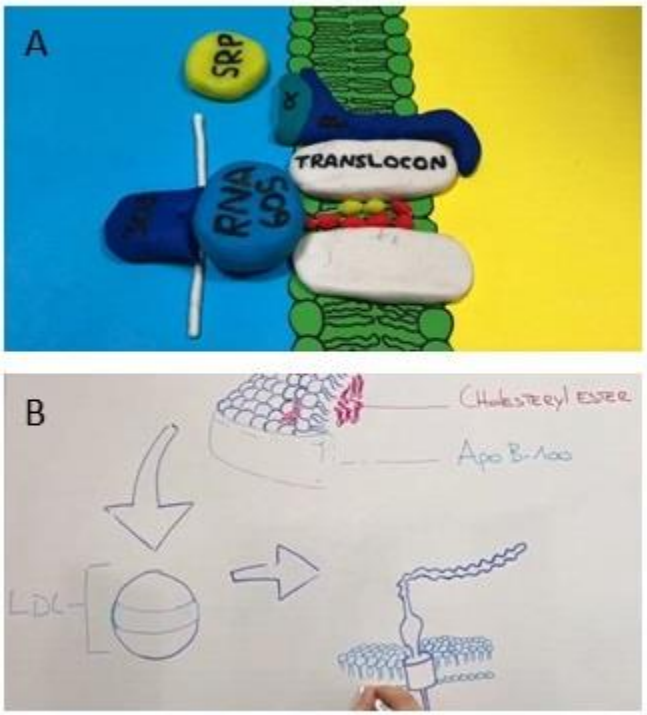

Figure 1. Examples of role-plays that used narrated animation and drawing to explain the assigned cellular process. One group used stop–go animation with shapes made from modelling clay to illustrate protein targeting to the endoplasmic reticulum (A), while another employed drawing on a white board to describe receptor-mediated endocytosis of low density lipoprotein (LDL) particles (B). Both role-plays used voice-over narration to explain the processes.

Table 1. Examples of the topics and casting for two role-plays. The cellular process that was the topic of the role-play is indicated as well as the student's overall concept for the performance. Most role-plays were centred on the targeting of a cargo protein to a specific sub-cellular location. Analogies made between the proteins / protein complexes / subcellular locations and the characters / locations in the role-play are indicated.

Topic: Protein transport from the ER to the lysosome **Concept for role-play: "The morning routine of a celebrity"** **Link to video:** https://youtu.be/oxOBMQhVtT0	
Protein / Organelle	**Analogy**
α-Galactosidase A [cargo for transport]	A celebrity
Oligosaccharyl transferase	Hairdresser
N-acetylglucosamine phosphotransferase	Chef
Phosphodiesterase	Cleaner
Mannose-6-phosphate (M6P) receptor	Stylist
Adapter protein 1 (AP1)	Personal Assistant
Clathrin	Bodyguard
Endoplasmic Reticulum	Bedroom
Cis-golgi	Kitchen
Trans-golgi	Living Room
Endosome	Lift
Lysosome	Car

Topic: Protein targeting to the mitochondrial matrix **Concept for role-play: "Girl trying to get into a nightclub"** **Link to video:** https://youtu.be/_OuFRZgTOIY	
Protein / Organelle	**Analogy**
Isocitrate dehydrogenase subunit [cargo]	Girl on a night out
Cytosolic Hsc70	Her Friend
Mitochondrial Hsc70	Nightclub Staff
Tom 20/22 import receptor	Bouncer
Tom 40 import pore	Nightclub Staff
Tim44	Nightclub Staff
Tim23/17	Nightclub Staff
Matrix processing protease	Nightclub Staff
Cytosol	Outside the club
Mitochondrial Matrix	In the club

Student feedback was obtained through an online survey using Google Forms. Eighteen responses to the survey were obtained. All respondents strongly agreed or agreed with the statement that "The assignment was useful, and I learned a lot form it". More specifically, they reported learning a lot about their own group's topic (4.8 on a 5-point scale) and learning somewhat less from watching the videos of other groups (3.2 on a 5-point scale). A couple of questions asked about the system of peer input into assessment of the assignment. When asked about students within a group providing input into the

marking for individuals in their group, 17/18 respondents felt that "it is a fair system that gives credit to those who do the most work" while only 1/18 indicated that they "would prefer if everyone in the group got the same mark". When asked "Would you prefer to do the role-play in class rather than shooting a video of it?" 100% of respondents expressed a preference for shooting a video. A selection of representative student's comments (edited for brevity) are shown below:

- "I found it extremely beneficial in making friends with people in our suddenly small course group……. It also helped me reach out to exchange students. Furthermore, it is the first project we have been assigned that entails teamwork and initiative skills and as a result, I was able to identify my weaknesses and strengths within a team."
- "It made learning extremely fun and unforgettable. I would love if other modules had a similar aspect to the coursework. The best thing about the group assignment was that it was pushing us to be creative and have fun with our ideas....."
- "I really enjoyed the assignment. I thought it was an excellent tool in learning……... Exercises like this should be the norm in our course."
- "As an international student, it helped me to meet other people in the class, which made me feel more welcome."

Conclusions

A result of giving students a large degree of freedom was the development of very novel analogies to explain their assigned cell biological process in some cases (Table 1). Analogies can help science students to conceptualize abstract ideas and things that are either microscopic or too massive to observe directly and are an invaluable tool frequently employed in teaching (Aubusson, Harrison, & Ritchie, 2006). Analogies link newly acquired concepts to previously known ones (Kiliç & Topsakal, 2011). To be most effective then, analogies must be made to concepts that students already know and can relate to. It is likely that the student, rather than the teacher, is best placed to identify such already-known concepts. Videoed role-plays of the type described here can thus be a source of novel and student-relevant analogies.

In summary the major benefits of this role-play exercise lie in facilitating students to:

1) Engage with members of their class including international students (generating a sense of camaraderie within the class)
2) Discuss a scientific topic in depth with each other (something that many will not do spontaneously) and thereby gain confidence for future literature and research projects
3) Engage in a team exercise, recognizing and developing their teamwork skills
4) Bring their non-scientific talents and skills to bear on a scientific assignment
5) Produce an output (the video) that can form part of a learning portfolio

These benefits contribute to interpersonal skills and other desirable graduate attributes that are unrelated to discipline-specific knowledge.

References

Aubusson, P. J., Harrison, A. G., & Ritchie, S. M. (2006). *Metaphor and Analogy in Science Education*. Dordrecht, The Netherlands: Springer.

Azman, S. S., Musa, N. N., & Mydin, M. M. (2018). Role-Play Analogy as an Approach to Learn Human Muscle Contraction. *Advanced Science Letters, 24*(5), 3436-3440. doi:10.1166/asl.2018.11403

Cherif, A. H., Siuda, J. E., Dianne M. Jedlicka, D. M., & Movahedzadeh, F. (2016). Not All the Organelles of Living Cells Are Equal! Or Are They? Engaging Students in Deep Learning and Conceptual Change. *Journal of Education and Practice, 7*(17), 74-86.

Chuck, J. A. (2011). Hypothetical Biotechnology Companies: A Role-Playing Student Centered Activity for Undergraduate Science Students. *Biochemistry and Molecular Biology Education, 39*(2), 173-179. doi:10.1002/bmb.20480

Craciun, D. (2010). Role-Playing as a Creative Method in Science Education. *Journal of Science and Arts, 1*(12), 175-182.

Kiliç, Ö., & Topsakal, Ü. U. (2011). The effectiveness of using student and teacher centered analogies on the development of the students' cognitive and affective skills. *Asia - Pacific Forum on Science Learning and Teaching, 12*(2), 1-16. Retrieved from

King, P. E., & Behnke, R. R. (2005). Problems Associated with Evaluating Student Performance in Groups. *College Teaching, 53*(2), 57-61. doi:10.3200/CTCH.53.2.57-61

Latif, R., Mumtaz, S., Mumtaz, R., & Hussain, A. (2018). A comparison of debate and role play in enhancing critical thinking and communication skills of medical students during problem based learning. *Biochemistry and Molecular Biology Education, 46*(4), 336-342. doi:10.1002/bmb.21124

McSharry, G., & Jones, S. (2000). Role-play in science teaching and learning. *School Science Review, 82*(298), 73-82.

Odegaard, M. (2003). Dramatic science: A critical review of drama in science education. *Studies in Science Education, 39*, 75-75+. Retrieved from

Shimazoe, J., & Aldrich, H. (2010). Group Work Can Be Gratifying: Understanding & Overcoming Resistance to Cooperative Learning. *College Teaching, 58*(2), 52-57. doi:10.1080/87567550903418594

Takemura, M., & Kurabayashi, M. (2014). Using Analogy Role-Play Activity in an Undergraduate Biology Classroom to Show Central Dogma Revision. *Biochemistry and Molecular Biology Education, 42*(4), 351-356. doi:10.1002/bmb.20803

Yang, C., Kim, K., & Noh, T. (2010). Influence of Method Using Analogy on Students' Concept Learning. *J. Korea Assoc. Sci. Edu, 30*(8), 1044-1059.