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Active peer mentored learning can improve student understanding of physiological concepts in an undergraduate journal club

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Abstract

One of the most ubiquitous active learning modalities in the biological sciences at third level is the journal club. Journal club can promote several beneficial learning outcomes for students such as gaining critical reading skills to evaluate the scientific literature, improving scientific literacy, serving as an introduction to new concepts and techniques and improving communication skills. However, it can be difficult for instructors who facilitate journal club to gauge student audiences' understanding of topics being related by presenters. At the University of Nevada, Reno School of Medicine, international life sciences undergraduate students enrolled in our research program undergo a 12-month placement in selected research laboratories within the medical school in order to develop an understanding of basic medical scientific research and physiological concepts. As such, an integral component of this program is participation in regular journal club sessions which we had assumed helped students to develop such an understanding . However as we had never empirically assessed if this was the case or not, . the aim of the current study was determine if student understanding could be improved by complementing the standard journal club with peer-mentored workshop presentations. Data from this case study suggest that by allowing students to undergo peer-mentored learning in conjunction with journal club, student understanding of physiological concepts, as well as student confidence in presenting and communication, increases.

Introduction

Active learning (*i.e.* any instructional method that increases students' involvement in the learning process by, for example, asking them questions or to participate during teaching (Bonwell & Eison, 1991) is increasingly being integrated into most areas of undergraduate education (10, 12). For example, active learning enhances student understanding of science,technology, engineering and mathematics (STEM) concepts and decreases failure rates in STEM courses (10).

Active learning can be encouraged through active teaching techniques such as implementation of team-based learning classes that can produce better examination scores than in courses compared reliant solely on traditional lecture formats (25). Further, in addition to boosting summative assessment scores, active learning in STEM fields has other benefits such as increased student confidence and knowledge, enrollment retention, and a narrowing of the achievement gap for underrepresented minority groups (4, 11–13).

One of the most ubiquitous active learning modalities in research-focused biological sciences for the last ~150 years is the so-called "journal club" (15). Here undergraduate or graduate students read and critically evaluate scientific articles, culminating in the presentation of their article appraisal to student peers. As such, journal club provides a multitude of beneficial learning outcomes for students such as an acquisition of critical reading skills with which to evaluate

scientific literature (5, 14, 18), improved their scientific literacy (8), an introduction to new concepts and techniques (3), improved overall student confidence (5) and presentation and communication skills that are a vital part of general professional and academic success (23, 27) (3, 8, 14, 15). Thus, by allowing students to participate in the scientific process by critically evaluating the literature, journal club also encourages students to begin identifying as scientists within a scientific learning community (11, 15, 17, 22).

Furthermore, journal club participation facilitates the types of higher order learning detailed in Bloom's taxonomy that are vital to become successful scientific practitioners (2, 6). For example, in journal club, science students must be able to critically analyze and evaluate data and concepts and then apply their knowledge of these data to create a cohesive appraisal of a piece of work, which they must then effectively communicate to their peers. Thus, journal club affords students the opportunity to exercise many key skills required of professional scientists.

However, in spite of all of the perceived aforementioned benefits of journal club it is difficult for instructors facilitating journal club to ascertain student audiences' understanding of topics being described by presenters. Indeed, although student audience members in journal club classes may appear to listen to and understand, without empirically assessing their understanding, the pedagogical

benefits of each journal club session are impossible to know. Therefore, such assessments are essential so that appropriate interventions can be implemented to address gaps in students' understanding.

At the University of Nevada, Reno School of Medicine (UNRSOM), international life sciences undergraduate students enrolled in our research program undergo a 12-month placement in selected research laboratories within the medical school in order to develop an understanding of basic medical scientific research and physiological concepts

As such, an integral component of this program is participation in regular journal club meetings.. However, as the effect of journal club on student learning of physiological concepts had never previously been assessed the present study sought to determine if student understanding of physiology could be improved by complementing the standard journal club format with peer-mentored workshops.

Methods

Student Background

A total of 11 life sciences undergraduate exchange students from universities in the islands of Ireland and Britain (three students (all female) from Queens University Belfast and eight students (six females and two males) from The University of Manchester). took part in the study All students were placed in different research laboratories in either the Department of Physiology & Cell Biology or the Department of Pharmacology at UNRSOM for 12 months. During

this period, they conducted research under the direct supervision of a senior principal investigator.

Journal Club Presentation Format

As part of their placement, students participated in a regular journal club which took place every Friday afternoon at 4pm for 45-60 mins during the fall (September – December 2017) and spring (January – June 2018) semesters. The11 students attended all journal club sessions along with a faculty facilitator (the same every week, no additional faculty were present), with each presenting once during both the fall and spring semesters (*i.e.* a total of two presentations during their placement program).

Prior to their designated weeks to present at journal club (during each semester)each student selected a paper relevant to their area of research and was asked to read the paper in detail beforehand to acquaint themselves with its main concepts and techniques. The paper would also be forwarded to all other members of the journal club five days in advance of each session, with the expectation that the other students would read it in time for journal club. During the journal club session itself, studentspresented information on the background to, and main findings of, the paper to their fellow students, whilst also also critically evaluating the data and the interpretations that had been drawn from them.

Students were encouraged to ask questions

Audience members were also actively encouraged to ask questions during each presentation to clarify any areas of confusion, a task that was assisted by the journal club faculty facilitator.. . Thus, the journal club sessions facilitated more discussion of, and interaction with, the presented material, than would occur in a traditional didactic lecture format.

Journal Club Topics / Themes

The research groups within either the Departments of Physiology & Cell Biology or Pharmacology at UNRSOM into which each student was placed all emphasized the regulation of vascular and visceral smooth muscle excitability. As such, students frequently encountered physiological concepts and themes that were being actively investigated within their own labs in many of the papers presented at journal club. Additionally, regardless of the techniques or physiological concepts explored in any particular journal club session, students were also encouraged each presenter to critically assess their papers for key criteria required to validate of data such as whether or not authors used appropriate controls (*e.g.* appropriate vehicle / time controls) and/or if the data in the paper represented values from an adequate sample size. Thus, the following six topics were regularly encountered during journal club:

1. Appropriate experimental controls

2. Cellular contractility

3. Electrophysiology

4. Ca^{2+}-dependent regulation of smooth muscle contraction

5. Interstitial cells in the GI tract

6. Cre-Lox P techniques.

Formative Assessment of Student Understanding

In order to quantify student understanding of the aforementioned concepts explored in journal club sessions, they were asked to complete an anonymous formative assessment at the end of the fall semester after all students had presented once (Test 1). The assessment contained 11 questions (worth a total of 22 points) Which assessed students' understanding of the following topics;

Q. 1 students' understanding of vehicle controls (1 point),

Q. 2 voltage-dependent excitation-contraction coupling (3 points),

Q. 3 appropriate experimental replicates in datasets (1 point),

Q. 4 Ca^{2+}-dependent excitation-contraction coupling in muscle (2 points),

Q. 5 confocal microscopy (1 point),

Q. 6 intestinal motility (2 points),

Q. 7 resting membrane potential (6 points),

Q. 8 global KO mouse models (2 points),

Q. 9 inducible knockout (KO) models (1 point),

Q.10 Cre-Lox P technology (1 point),

Q.11 electrophysiology and relationship of voltage and current (2 points).

Students were provided with 50 mins to complete the test without conferring with other students. The scores of all 11 student quizzes were tabulated as a percentage.

Active Peer Mentored Presentations

After marking, any questions from Test 1 that had been answered poorly (indicating a lack of student understanding in those areas) were noted and those areas designated for intervention. Thus, in an attempt to improve student understanding of these areas, students were organized into pairs before beginning the Spring semester of journal club and asked to develop a peer-mentored presentation on an area highlighted by low scoring in Test 1.i. . These peer-mentored presentations consisted of six different topics, with each student-pair assigned to one presentation (except for a single student who was assigned by random draw to work on two presentations, due to the odd number of students in the group). Each presentation lasted 30 mins, with each student presenting for

15 mins apiece. Audience questions were encouraged throughout these presentations, with a further 15 min question and answer session following each presentation, where the presenters asked questions of the audience to ascertain if they understood what had just been presented to them. Two such sessions were performed from 4-5 pm on a Friday afternoon for three consecutive weeks before regular journal club sessions resumed. As with the Fall journal club sessions, each student presented a paper once during the Spring semester (January – June 2018). At the conclusion of the Spring semester journal club schedule (June 2018), students completed the same formative assessment originally taken in December 2017. Students were not told that they would be asked to complete the same formative assessment again ahead of time. The results from this second quiz (Test 2) were then calculated as a percentage out of 22 points.

Using GraphPad software the scores of both tests (before and after peer mentoring) were compared using an unpaired student *t* test (as both formative assessments were anonymous, it was not possible to directly compare the results of one student over both the Fall and Spring semesters without losing student anonymity) with a Welch's correction (comparison of mean score) and also with a non-parametric Mann-Whitney test (comparison of the distribution of all score values). P values <0.05 were taken as significant for all statistical tests.

After the completion of the second semester, all students completed an anonymous five-item survey of their experience with journal club and the peer-mentored workshops and how these impacted their learning throughout both semesters. Items 1-3 in this evaluation were assessed on a Likert scale (Strongly Disagree, Disagree, Don't Know, Agree, Strongly Agree). ***Q.1: "****The peer-mentored workshop implemented in January 2018 enhanced my understanding of physiological concepts and techniques encountered in journal club."* ***Q.2:*** *"The peer-mentored workshop in January 2018 contributed to my ability to answer questions correctly in the assessment taken in Summer 2018."* ***Q.3:*** *"I felt better prepared for journal club following the peer-mentored workshops."* The fourth question was a binary choice, ***Q.4:*** *"Which semester of journal club was of most benefit to your learning: semester 1 (without workshops) or semester 2 (with workshops). Examples of learning can include, but are not limited to, presentation skills, scientific literacy, ability to critically evaluate data, ability to discuss science with peers, confidence in handling difficult or critical questions."* The final survey item was open-ended: **Q.5:** "*Please provide any further comments about journal club or the peer-mentored workshop that you feel are relevant (positive or negative)."*

Results

As shown in Fig.1, the mean score for all eleven students in Test 1 was 60.1 ± 5.6 % (minimum score, 22.7 %, maximum score, 90.9 %. The distributions of all scores in Test 1 are shown as a frequency histogram (light bars) in Fig. 1A. Based on these results and specific questions answered correctly / incorrectly, areas in need of intervention were identified and peer-mentored workshop presentations were used to facilitate student learning in these areas as described in the Methods.

As shown in histogram Fig.1A (black bars) for Test 2, which was taken after completion of the peer-mentored workshop presentations and another semester of journal club, the scores were significantly enhanced relative to Test 1, with a mean score of 77.5 ± 5.6 % (P=0.028; Mann Whitney), some 17.4% greater than in Test 1. (Fig.1B, P=0.03, unpaired *t* test). I is also worth noting that the minimum student score in Test 2 was 54.6%, which was a 31.8% increase from the minimum score in Test 1 (22.7%). The maximum score also increased between Test 1 and 2, from 90.9% (attained by a single student) in Test 1 to two students attaining perfect 100% scores in Test 2 (Fig.1A).

As shown in Fig.2, in the end of program survey, all students responded positively to Q.1-3 (described in methods and Fig. 2). When asked if the peer-mentored workshops positively affected their conceptual understanding of

physiological concepts encountered in journal club, 100% of students selected ‘Strongly Agreed’ or ‘Agreed’ (Fig. 2, Q.1). 100% of students also selected ‘Strongly Agreed’ or ‘Agreed’ when asked if the peer-mentored workshops contributed to their ability to successfully complete the formative assessment in the Spring semester (Fig. 2, Q.2). All students also selected ‘Strongly Agreed’ or ‘Agreed’ when asked if the peer-mentored workshops better prepared them for journal club (Fig. 2, Q.3). When asked which semester of journal club was of most benefit to their learning, the majority of students (81.8%) selected semester 2 (with workshops, Fig. 2, Q.4). The full responses to the open-ended question for feedback on journal club and the peer-mentored workshops are presented in the Appendix (note that one student did not complete this section of the survey and thus only 10 responses are presented).

Discussion

In the current study, we sought to quantify the effect of journal club attendance on undergraduate student understanding of physiological concepts and to also determine if this understanding could be improved by complementing the standard journal club format with peer-mentored workshops.

The first formative assessment conducted at the end of the Fall semester, demonstrated that student learning following several journal club sessions was somewhat limited. Because of this finding, we introduced peer -mentored workshops to try and increase active learning in journal club the following

semester. Peer mentoring has been noted to provide many benefits to student learning such as promoting facilitative learning (16), decreasing student anxiety (as they are working with a peer and not afraid of appearing to be ‘wrong’ to an authority figure) (19, 20) and promoting improved general exam performance in STEM courses (4, 7). Interestingly, peer-mentoring also enhances student understanding of STEM concepts even if no students within a group knows the correct answers or grasps the key facts at the outset of a course (24).. Furthermore, in both undergraduate and graduate level biology / medical courses peer-mentoring workshops dramatically enhance student engagement and learning (13, 21), increase graduation rates and reduce failure rates in STEM courses (1, 13).In the current study we also found that implementing peer-mentored workshops, significantly increased overall student understanding of general experimental and physiological concepts d, as assessed by formative assessment 2. Taken together, our data suggest that appropriate active learning interventions such as peer-mentored workshops can be a useful approach to enhancing student understanding of general scientific and physiological concepts within an undergraduate journal club program. Similar to journal club, peer-mentoring places the responsibilities and teaching commitments directly on to students. As such, students must take ownership of the material so that learning can occur (16). Whilst in traditional journal club sessions, this responsibility is placed solely upon the student presenting, peer-mentoring facilitates co-operative learning and enhances the sense of a learning community. Our data from this case study suggest that this peer-mentored workshop approach may be

a valuable addition to traditional journal club classes. We intend to repeat and expand this study with different cohorts of students enrolled in other STEM graduate classes that utilize journal club to evaluate if this trend holds true amongst different groups of students.

One limitation of this study was that it was not possible to control for factors other than the peer-mentored workshops that may have led to an increase in student scores in the second assessment. It is possible that as the assessment was the same for both tests, students may have been 'primed' to those questions the second time around and therefore more likely to answer them correctly. However, if we had not used the same assessment then it would have been impossible to directly compare student performance between Test 1 and Test 2. Furthermore, we suggest that as the students were not given a copy of the formative assessment and that they completed the two tests a full 6 months apart, students were unlikely to be fully 'primed' to the formative assessment questions for Test 2. Despite this limitation, evidence from the student evaluations completed at the end of the year suggests that the implementation of the peer-mentored workshop was a major factor in the increase in student scores between the two semesters.

In their evaluation, when asked the open ended question "*Please provide any further comments about journal club or the peer-mentored workshop that you feel*

are relevant (positive or negative)", many students commented that the use of the workshops greatly increased their confidence in presenting scientific data, participating in peer-review and handling critical questions. This was also evidenced by the fact that all students at least agreed with the statement *"I felt better prepared for journal club following the peer-mentored workshops."* In fact, in the open-ended request for feedback on journal club and the workshops (Q.5), many students stated that the workshops were so beneficial (enhanced scientific literacy, increased confidence in presenting, reading papers) that they proposed similar workshops should be conducted at the very start of the academic year to "kick start" the learning process in the first semester for future students. Some of the feedback from students related to this topic included statements such as, *"Workshops should first be done at the start of the year to give everyone a basic understanding of the topics that will be discussed throughout the year",* while another student commented, *"I think that it would be beneficial to have the workshops at the start of the year as a lot of us had never studied electrophysiology before and therefore most of the concepts were new which made presenting an entire paper related to the subject quite challenging. I definitely felt more confident presenting papers after the workshops!".*

There was also a common positive appraisal of journal club in general from all 11 students, with students commenting that it helped with their scientific literacy, typified by one student stating, *"All together, the journal club helped with reading research papers properly, and understanding how to critically evaluate it. Which*

is really important. I do not find reading research papers as difficult anymore." Another common theme was that students commented that journal club had made them more confident with delivering presentations in general, *"We have done numerous presentations already this year but I feel much more confident going in to them and also more confident in my ability to answer questions."* Thus, whether relating to scientific literacy or communication in general, there was a common thread of *increased confidence* in the students after the peer-mentored workshops. Further studies should pursue this observation to determine other modalities that may facilitate increased student confidence in undergraduate classes. Overall, the feedback suggested that the increase in formative assessment student scores was at least partially due to the positive effects of the peer-mentored workshops and that students overall found such workshops beneficial in enhancing their learning experience within the journal club module.

In conclusion, data from this case study suggest that by allowing students to undergo peer-mentored learning in conjunction with journal club sessions, student understanding of physiological concepts, as well as student confidence in presenting and communication increases.

Appendix: Student responses to survey Q.5 "*Please provide any further comments about journal club or the peer-mentored workshop that you feel are relevant (positive or negative).*"

1. Journal club has provided me with several sets of skills including data analysis, presentation of my own data and how to critique data to know what's good and not so good.
2. I like that the workshop PowerPoints were circulated around the group as I still use them to review certain areas. Both the workshops and journal club have really helped me with presentation skills, it enabled me to get away from scripting my presentations and I think I am a much better presenter because of that as it flows much better. It set us up very well for the end of year symposium and also for final year. We have done numerous presentations already this year but I feel much more confident going in to them and also more confident in my ability to answer questions. I did find it very difficult to get up and present to my peers at the beginning but it was something I needed to learn to deal with and it has been of great benefit to me this year.
3. Workshops should first be done at the start of the year to give everyone a basic understanding of the topics that will be discussed throughout the year.
4. Good structure to journal club, helped my learning and broadened my knowledge on other fields not just my own. Greatly helped with end of year symposium.

5. I really enjoyed the variety of things we did in the journal club, e.g. presentations (alone or in groups), critically evaluating papers and receiving feedback on our own data. Overall, very enjoyable and beneficial!

6. All together, the journal club helped with reading research papers properly, and understanding how to critically evaluate it. Which is really important. I do not find reading research papers as difficult anymore.

7. The journal clubs were great, they were very professional and definitely helped me develop scientific thinking. They also helped me improve presentation skills and the ability to explain complex scientific mechanisms in a straightforward way. Establishing people's levels of knowledge at first (e.g. through workshops) before moving into papers would be a great order for organizing journal clubs.

8. It was a good experience and I strongly recommend it in order to improve our understanding of physiological research, especially because most of us were not familiar with it previously.

9. I think that it would be beneficial to have the workshops at the start of the year as a lot of us had never studied electrophysiology before and therefore most of the concepts were new which made presenting an entire paper related to the subject quite challenging. I definitely felt more confident presenting papers after the workshops! Overall journal club has been invaluable in improving my presentation and analytical skills.

10. Journal club was a great way to get used to presenting and discussing research and was a very valuable thing to do. The workshops were beneficial and would be

good to have at the beginning of the year. One improvement that could be made is that the journal clubs tend to be focused on the SIP syncytium/smooth muscle when there are some students who don't work on that. It might be good if their workshop could feature some of the scientific background/techniques from their work in more detail.

11. I found the peer-mentored workshops very beneficial and believe that they may be more useful for future students to start with. Overall journal club was great and I always looked forward to it!

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Conflicts of Interest

None.

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Figure Legends

Fig. 1: Distribution of student scores in Test 1 and Test 2. ***A*** Frequency distribution showing the scores (%) of all eleven students from the completed CA for Test 1 (light bars) and Test 2 (black bars). ***B*** Summary data comparing the mean score (%) of all students for Test 1 (light bars) and Test 2 (black bars). n=11, * = P=0.03.

Fig. 2: Student evaluation feedback. Summary data showing student responses for Q.1-4 on the student self-evaluation form completed by all students at the conclusion of the academic year. n=11.