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Promoting Active Learning in Physiology Lectures Through Student Response Systems: To Click or Not to Click

Pierre Thibeault

The University of Western Ontario, pthibeau@uwo.ca

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ABSTRACT

Courses in physiology engage students through active learning strategies including small group discussions, group work, and opportunities to explore a scientific problem and explain their findings. Many of these active learning exercises take place in tutorial and laboratory settings. Unfortunately, traditional physiology lectures are often limited to conveying information through lecturing and PowerPoint slides. This approach provides little opportunity for student engagement above lower-order cognition, i.e., writing notes, listening, memorization (Freeman et al. 2014). Student response systems (e.g., clickers) are a valuable tool to facilitate active learning in the lecture setting that could enable students to take control of their learning (“Do I truly understand this topic/concept/theory?”) (Hwang, Wong, Lam & Lam 2015). In addition, clickers provide valuable instant feedback to the lecturer about student comprehension, and can be used to track participation and attendance. Many platforms are now available including clicker devices and virtual clickers to facilitate active learning and meta-cognitive exercises in the lecture setting. Student feedback response platforms may provide a way to introduce active learning into the lecture setting with physiology lectures resulting improved engagement and better achievement of learning outcomes. This workshop provides practical strategies and examples to help instructors evaluate the benefits, challenges, and methods of integrating student response systems into the physiology lecture setting.

KEYWORDS

student response systems; active learning in lecture

LEARNING OUTCOMES

By the end of this workshop, participants will be able to:

- Identify the benefits of clicker integration into lectures.
- Discuss novel applications for clickers in lectures and demonstrate examples of active learning activities that rely on clickers.
- Discuss obstacles to implementation and use, and devise strategies to overcome obstacles.

ANNOTATED BIBLIOGRAPHY

Freeman, S., Eddy, S. L., McDonough, M., Smith, M. K., Okoroafor, N., Jordt, H., & Wenderoth, M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences of the United States of America*, 111(23), 8410-8415. <https://doi.org/10.1073/pnas.1319030111>

Traditional lecture typically involves two distinct roles: (1) the lecturer is tasked with the dissemination of course materials and concepts; and (2) the student is responsible to be attentive, take notes, and be present to learn the information that is being provided to them. This traditional lecture setting promotes a “teaching by telling” approach where the engagement of the student is limited to lower-order cognition (note taking and memorization). The authors of this article argue that there is a multitude of published literature suggesting the necessity for students to have ownership of the material they are learning - that is, they must

not only receive material but be provided opportunity to critically evaluate the material and assess their understanding/lack of understanding to achieve optimal learning. The authors performed a meta-analysis of 225 existing publications to determine the effect of the presence/absence of active learning on student performance (examination scores, failure rates) across various science, technology, engineering and mathematics (STEM) lecture courses. The authors report that the use of active learning strategies (group-problem solving, tutorials, clickers, etc.), in contrast to traditional lecturing resulted in improved student performance on examinations/evaluations and decreased course failure rates. This article provides a proof of concept foundation for the workshop identifying the benefits of integrating active learning into the lecture setting. Facilitators should use this publication as a tool to introduce the concept of active learning and how these practices can have a meaningful impact on student learning and their subsequent engagement and academic performance.

Hwang, I., Wong, K., Lam, S. L., & Lam, P. (2015). Student response (clicker) systems: Preferences of biomedical physiology students in Asian classes. *Electronic Journal of e-Learning*, 13(5), 347-356.

Student-teacher interaction within a lecture is an important component of student learning. As an instructor, it is critical to assess how to best foster a classroom environment that facilitates this interaction. A common challenge that instructors encounter in lectures (particularly in large classrooms) is students may be too shy to ask questions which may reveal that they do not understand a concept. Additionally, when presented with questions about content there may be a core group of students that answer questions leaving many other students without a voice in the classroom. One method for addressing these challenges is the integration of audience response systems (clickers). This allows more students to participate in the question-answer process, anonymous submissions removing the potential for discomfort voicing questions among peers, and instant feedback to students and instructors regarding concept knowledge. Hwang and colleagues set out to evaluate preferences to the use of physical and virtual clickers within a diverse set of classrooms (undergraduate and postgraduate; nursing, pharmacy, human biology, etc.) The authors found through two studies that students were positive about the use of clickers, and reported improved engagement in the lecture. Student responses to questions regarding 'understanding' revealed that the clickers were particularly useful to students in assessing whether they understood a concept. This article is particularly beneficial to this workshop for establishing participant beliefs about clicker use and benefits. The authors continue past their initial two studies to discuss some of the benefits and challenges to each of the two types of clicker (physical or virtual). The facilitator should familiarize themselves with the two modalities and the benefits/challenges associated with each to guide group discussion.

Kim, Y., Jeong, S., Ji, Y., Lee, S., Kwon, K. H., & Jeon, J. W. (2015). Smartphone response system using twitter to enable effective interaction and improve engagement in large classrooms. *IEEE Transactions on Education*, 58(2), 98-103.
<https://dx.doi.org/10.1109/TE.2014.2329651>

Interactions between students and instructors becomes increasingly difficult as class size is increased, making it difficult for instructors to assess student understanding of concepts, address the variety of student questions without becoming too individualized, and maintain classroom engagement. One frequent concern with clicker use is the cost associated to the university or students for the purchase and use of physical clickers. In recent years, numerous online platforms have been established that can address this concern. The current study evaluates virtual clicker use on social network systems (SNS). This study used Twitter for a series of pop quizzes and surveys in a large lecture setting with the intent to determine the effect of this virtual clicker platform on student learning. Additionally, the study included surveys to assess whether virtual clicker use on smartphones affected students' use of smartphones for non-academic purposes. The authors found that the use of Twitter-based responses had a positive impact on student performance on examinations. Student responses to survey questions regarding their concentration, involvement and the concentration of their colleagues indicate that there was a positive shift in response following the use of the proposed platform. A common concern with platforms of this nature is that students will be distracted from the lecture. Interestingly, the authors found that the use of smartphones for non-academic purposes decreased when the Twitter-based response system was integrated. This article provides valuable insights into the effect of SNS/smartphone-based platforms for student responses. This article provides the facilitator with an evidence-based approach to a common concern with virtual clicker use. It is anticipated that this will be presented as a challenge through group discussion and can be addressed through the discussion on overcoming barriers to use.

Miles, N. G., & Soares da Costa, T. P. (2016). Acceptance of clickers in a large multimodal biochemistry class as determined by student evaluations of teaching: Are they just an annoying distraction for distance students? *Biochemistry and Molecular Biology Education*, 44(1), 99-108. <https://dx.doi.org/10.1002/bmb.20917>

Modern undergraduate classrooms are adapting to facilitate various learning environments - lectures (face-to-face, F2F), blended-learning (some division of time between F2F and online), and online-only. In this study, the authors sought to determine whether the use of clickers in a recorded F2F lecture were a distraction for distance education students. Close-ended questions in addition to open-ended comments were analyzed to determine if the benefit of clicker use was maintained between the F2F and distance education cohorts. The authors reported that responses between both the F2F and online learning groups were generally positive to clicker use, particularly when paired with an explanation of answers through annotated figures. This article addresses concerns for situations where a lecture is recorded and used for an online cohort of students. Specifically, the article provides evidence that clicker strategies should not be discouraged in such situations, as the responses and subsequent explanation of concepts was also beneficial to distance education students.

Moss, K., & Crowley, M. (2011). Effective learning in science: The use of personal response systems with a wide range of audiences. *Computers & Education*, 56(1), 36-43. <https://dx.doi.org/10.1016/j.compedu.2010.03.021>

Lectures maintain a stronghold in undergraduate education as a primary modality for conveying course materials. One of the challenges associated with the traditional lecture is the approach that the instructor has knowledge that the student does not possess and thus students are 'empty vessels' waiting to be given instruction. While it is true that the lecturer has knowledge that the students require and do not currently possess, constructing the lecture around the conveyance of knowledge and the passive learning of students (note taking and memorization) may not be the best method for student learning. In fact, there are a multitude of studies demonstrating that passive learning is not the optimal way to promote student learning. In this article, the authors discuss the use of clicker systems to promote active learning. The authors propose that clicker response systems can be used for higher-order cognitive exercises such as fill in the blank, rating scales, numbering, multiple choice and small peer discussion questions to enhance the understanding of complex scientific questions. This article provides an excellent resource to the workshop facilitator as it aptly outlines the various applications of personal response systems in a variety of settings including the traditional lecture. Instructors can find ways to phrase questions around complex scientific ideas that promote higher-order cognition and can even be extended to meta-cognitive processes through reflection and discussion of the questions. The article also outlines some practical guidelines for equipment use and purchasing (such as which receiver type, infrared or radio, is best for your classroom, etc.). The facilitator should use this article to explain examples of active learning exercises that can be conducted through clicker use.

Smith, M. K., Wood, W. B., Krauter, K., & Knight, J. K. (2011). Combining peer discussion with instructor explanation increases student learning from in-class concept questions. *CBE-Life Sciences Education*, 10(1), 55-63. <https://dx.doi.org/10.1187/cbe.10-08-0101>

A strategy to promote active learning with student response systems is to integrate peer discussion and/or instructor explanation of the answer. Following clicker responses, instructors may explain why an answer was correct and why other answers were not correct. Peer discussion involves allowing time for students to turn to a peer or small group around them and discuss a question before answering with their clicker. The current study examines whether instructor explanation alone or in combination with peer discussion is most effective. The authors examined endpoints between the first and second quarter (Q1 and Q2, respectively) of an undergraduate genetics course. They looked for two indicators of student performance, number of correct answers and mean scores from Q1 to Q2, between major and non-major participants as well as weak, medium, and strong performers. The authors report that both the percentage of correct answers and mean scores between Q1 and Q2 were improved for both majors and non-majors when instructor explanation and peer discussion were combined (as compared to either intervention separately). Additionally, they report that the most significant learning gains were gained by weak and medium answering students. The workshop facilitator could use this article to discuss ways in which clicker questions can be made into meaningful active learning opportunities.

WORKSHOP CONTENT AND ORGANIZATION

DURATION (min)	SUBJECT	ACTIVITY	PURPOSE
10	Introduction/ Icebreaker	<p>Introduce yourself and explain the workshop's intended outcomes and structure.</p> <p>Icebreaker: Participants will be asked to introduce themselves and briefly mention if they have taught a lecture/been taught in a lecture that used clickers and how that impacted the lecture.</p>	<p>To introduce the facilitator and the workshop focus/structure.</p> <p>To pre-assess participants, and gauge who is familiar with student response technologies.</p>
10	Group Discussion: Methods and Challenges of Engaging Students In Large Classes	<p>Ask participants to describe ways in which they engage and assess their students in the lecture setting and discuss challenges they may/have encountered in a lecture setting.</p> <p>Prompt: <i>"In your lectures, what strategies do you employ to ensure that students are engaged and meeting the learning outcomes? What are some of the challenges you have encountered with engagement/assessment in a lecture?"</i></p> <p>Give the floor to participants to share one way that students could be engaged and one challenge to assessing learning outcomes in a lecture setting.</p>	<p>To have participants reflect on their own experiences in lecture and to share their strategies for engagement.</p> <p>To encourage participants to identify the challenges of engaging students and of assessing student achievement of learning outcomes.</p> <p>Sharing experiences within a diverse group enables participants who may not have had experience lecturing their own classes to hear some of the challenges that can be encountered and begin to think about how and why we engage/assess students.</p>

5	How Do We Engage and Assess Students in Lecture?	Drawing on Freeman et al. (2014), discuss some of the ways that students are currently engaged and assessed in lecture settings and the challenges that accompany these pedagogies.	To connect the group discussion to published research on the topic.
15	Using Clickers in Physiology Lectures: "To Click or Not to Click"	<p>Drawing on Hwang et al. (2015), present the benefits of integrating clickers into a STEM lecture including increasing overall grade outcomes and content retention, improving student engagement, and instant feedback for assessment.</p> <p>Refer to Moss & Crowley (2011) and Smith et al. (2014) to discuss novel applications for clickers in physiology above and beyond the traditional activity of multiple choice polling. Provide examples of how clickers can be incorporated into more complex active learning activities.</p>	<p>To introduce the benefits of clickers established in the literature.</p> <p>To focus on how clickers can be used effectively and creatively in physiology lectures.</p>
15	Clicker Challenges	<p>Initiate a small group discussion with participants:</p> <p><i>"What are some of the challenges or barriers to implementing clickers into the lectures?"</i></p> <p>(e.g., cost, technological limitations, potential distractions, etc.)</p> <p>Following small group discussions, the groups will come back together to share some of the challenges they have identified.</p>	To encourage participants to think about the challenges of implementing clickers into their individual department and lecture context.
10	Overcoming Challenges	Sharing ideas from Kim et al. (2015) and Miles and Soares da Costa (2016), present ways to overcome common barriers such as cost, technological problems, and student distraction. (e.g., virtual clickers to reduce/eliminate cost; and literature supporting that clicker use improves student attention)	To provide participants with practical strategies to avoid/overcome barriers.

15	Small Group Discussion	<p>Pass out the handout with example multiple choice clicker questions (Appendix A).</p> <p>Ask participants to read example questions and discuss how each example could be modified to become a more complex active learning activity.</p>	To get participants to design innovative active learning activities that incorporate clickers.
20	So I Want to Use a Clicker, Now What?	<p>Lead a discussion about current available technologies including any that are preferred on campus.</p> <p>Demonstrate one technology by inviting participants to respond to a few questions (see sample questions in Appendix B) using their smartphones or laptops. Afterwards, demonstrate how to set up the activity.</p> <ul style="list-style-type: none"> Facilitate the activity using an institution-specific program or use a publically accessible program (e.g., Kahoot! or Socrative). 	<p>To demonstrate the diversity of available student response systems, and to introduce current or institution-specific technologies.</p> <p>To demonstrate the ease of using a virtual clicker system.</p>
20	Small Group Discussion And Closing Remarks	<p>Give participants the opportunity to discuss and share how they plan to implement clickers in their future teaching to help students achieve class or course learning outcomes.</p> <p>Thank participants for attending and discussing. Dismiss the session.</p>	To provide an opportunity for reflection and goal setting.
Total Time: 120 minutes			

PRESENTATION STRATEGIES

This workshop introduces student response system clickers providing evidence and examples to support their use.

Facilitator talking points:

- Clickers provide a unique opportunity to engage all students in the lecture setting as compared to having a select group of apt students answering for the class.
- Clickers also provide instant feedback to the instructor for the evaluation of the groups grasp of course content. For example, an instructor may find through a clicker question

that much of the class answered incorrectly on a key concept. The instructor could then re-highlight that concept and follow up with another concept checking question in a following lecture.

- Instant feedback is also beneficial for the student learning experience. Instant feedback provides each student with the opportunity to assess if they truly understand a concept in an anonymous manner.
- Anonymity within response systems enables those students that would often be too shy or apprehensive to ask a question among their peers to have an opportunity to demonstrate their understanding of a concept.

There are several active learning exercises embedded within this workshop including small group discussion, group discussion, and meta-cognitive exercises. Participants will leave the workshop with the ability to describe the benefits of clicker integration into lectures and how to use clickers for active learning. Further, participants will receive a hands-on demonstration using a common technology chosen by the facilitator.

The facilitator could prepare a PowerPoint presentation based on the annotated bibliography to share at relevant points during the workshop. The facilitator should also choose a student response system and prepare questions in order to demonstrate the technology during the workshop.

The facilitator is advised to have access to:

- A room with:
 - Tables seating 4-5 people arranged with enough seating for 15-20 people
 - Audio/visual equipment to display PowerPoint slides
 - White board and markers to record group discussion points
- Appendix A handouts for all participants
- Coffee/tea and snacks

APPENDIX A: Sample Group Handout

As a group, read the following sample physiology questions. Once read, discuss strategies for turning these clicker questions into a more complex active learning activity.

1. A patient has received damage to their left motor cortex. What of the following symptoms would you best expect?

- a) A loss of coordinated movement on the left side of their body
- b) Inability to feel their right leg
- c) Spontaneous uncontrolled movement of the right side of their face
- d) A constant burning sensation radiating from the left side of their body
- e) Paralysis of their right arm

2. Which of the following is false regarding actin/myosin interaction?

- a) At rest Tropomyosin blocks actin/myosin interaction
- b) Calcium release is required to remove Troponin-c from actin to produce a muscle twitch
- c) The power-stroke is completed by the binding of ATP to myosin
- d) Removal of calcium is required for muscle relaxation
- e) Actin/myosin cross-bridges can form only when myosin is ADP-bound

APPENDIX B: Student Response System Demonstration Questions

Set up several multiple choice questions prior to the workshop using a response system of your choice. Questions can be related to demographic data, key messages, or feedback on the workshop.

Demographic Question

I have been teaching for...

- a) 10+ years
- b) 5-10 years
- c) 1-5 years
- d) <1 year

Key Messages Question

Which of the following statements is NOT true?

- a) Student response systems increase class participation.
- b) There are no known barriers to using clicker technologies.
- c) Students respond positively to clicker activities.
- d) Instructors use student response systems to assess understanding.

Workshop Feedback Question

Now that I have participated in this workshop, I feel confident about implementing student response systems into my teaching.

- a) Strongly Agree
- b) Agree
- c) Disagree
- d) Strongly Disagree