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Fun with Videos: Difficult Concepts Made Accessible

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User-friendly multimedia tools focused on conceptual trouble spots cater to multiple learning approaches, promote the use of interactive techniques such as iClickers and Peer Instruction, and augment required reading. We hypothesize that once a concept has been introduced, students who have explored the subject at their own pace through the use of well-designed online tools will be more likely to engage in stimulating discussion, derive greater benefit from the curriculum, and are less likely to commit errors. We demonstrate the use of an innovative technology, the Learning Glass, using one physiological concept and one numerical concept. We explore the student experience with a difficult microbial physiology concept, hydrogen sulfide production, using the Kligler Iron Agar and its corresponding online tool. Sample segments of the Kligler online tool can be viewed at: http://webstage.ucsd.edu/ilti/Preview/ECON-IMVH/Biolabpromov2.1080p-crf23.mp4.

Keywords: Concept videos, Learning Glass, Online

Introduction

The 2011 American Association for the Advancement of Science (AAAS) document entitled Vision and Change in Undergraduate Biology Education: A Call to Action (http://visionandchange.org/files/2011/03/Revised-Vision-and-Change-Final-Report.pdf) is a summation of recommendations for the improvement of undergraduate biology education. Listed under the action item "Focus on Student Learning" are the recommendations to "Engage students as active participants, not passive recipients", "Use multiple modes of instruction in addition to the traditional lecture", "Ensure that undergraduate biology courses are active, outcome oriented, inquiry driven, and relevant", and "Facilitate student learning within a cooperative context". The curriculum for our undergraduate upper division Microbiology lab course is designed to meet these goals and incorporates authentic research and innovative combinations of microbial physiology and quantitative microbiology, and provides opportunities for students to develop scientific literacy, numeracy, and critical thinking ability.

Students in this class come from a variety of majors and a range of prior exposure to microbiological concepts and techniques. Working with this mixed demographic can be challenging and seriously undermine our efforts to raise the level of critical analysis. It is often also unclear as to which category poses more problems – students with prior experience who have picked up technique errors and concept misconceptions or students with no prior experience who struggle with the complexity of the concepts. Nevertheless, it is imperative that all students are at the same level of familiarity with the foundational information while exploring the intricate interlinking of microbial physiology. The lab manual and associated material have frequently been described as organized and comprehensive. Not entirely unexpectedly, however, the most difficult aspect of teaching has been to ensure that students read the manual and understand the basic information sufficiently well to benefit from the interactive learning process.

Conventional methods of incentivizing reading including pre-class quizzes, pre lab writeups, iClickers graded for accuracy as well as participation, and bonus points for questions based on selected reading all had limited success. Our new approach is to increase the challenge and flip some portions of the course, and to support this structure with instructional videos targeting the concepts that are consistently either poorly understood or significantly misunderstood. The concept of flipping a class is not new. Most subjects have content that consists of foundational information of various levels of difficulty, as well as content that lends itself to a deeper understanding through problem solving and discussion. Flipping a class involves structuring the learning process such that students prepare before class using guided tools, allowing the use of in-class time for interactive learning through peer instruction (Mazur, 2009), group learning, audience response systems (e.g iClickers), etc. Our approach takes advantage of the fact that lab courses are to some degree already inherently flipped and have the advantage of using a more experiential learning modality than lectures. There is ample published evidence for the efficacy of using pre-class videos and simulations (Herreid et al, 2013, Perkins et al 2006) in combination with pre-class online quizzes or associated homework to measure understanding. We believe that these videos extend the hands-on learning experience into the lecture room.

We currently have videos for a variety of topics including Safety in a Microbiology Lab, all aspects of Brightfield and Phase Contrast Microscopy, Understanding Dilutions, Sterile Technique, Hydrogen sulfide production and the Kligler Iron Agar, with videos on a Transposon Mutagenesis experiment currently in production. Technology used includes conventional videotaping using actors, animation, green screen, small and large Learning Glass, and in-lecture videotaping with modifications to allow interactive evaluations of learning outcomes. These videos are tailored to our particular needs but are also sufficiently universal to allow use in a wide variety of academic and non-academic settings from high school and college to clinical labs. Here we briefly describe the process by which the videos were designed, produced and implemented in the classroom, with particular emphasis on the Learning Glass video technique.

Materials

The Learning Glass can be purchased from http://www.learning.glass/learning-glass-products/ Similar versions can also be assembled from component parts and customized to the specific budget and needs of the college or university. The following components were used at our university:

1. ½' thick low-iron tempered glass with mounting brackets and side support brackets.
2. Airtouch adjustable height table to mount the glass. The table height can be adjusted according to the height of the user.
3. Fluorescent lights and diffusers to provide soft, even light, and reduced heat.
4. Video camera: currently the 4K Sony PXW-FS7.
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6. Wired lavalier microphone.
7. Teleprompter: This needs to be carefully angled not to reflect on the glass when videotaping.
8. Orei XD-2000 Video Scalar to mirror or invert the video signal. This is necessary if the video camera does not have this function.

More information on parts and assembly can be obtained from the Educational Technology Services at UCSD.

Instructions on how to videotape are specific to the equipment and services provided at each college or university and will not be addressed here.

Notes for the Instructor

There is no student outline since this article describes how instructors can set up a resource that can be adapted to existing experiments. The following is provided to explain the process of preparing the resource and examples of how they were implemented, with the understanding that implementation will vary widely based on the specific needs. This also explains how Learning Glass was set up at our university and how we created a video using this technology.

How Learning Glass Works

Invented by Matt Anderson in collaboration with Mark Hatay, both of San Diego State University, the Transparent White Board Technology is an innovative technology that uses a transparent whiteboard to convert conventional videotaping of lectures into a very viewer friendly, natural, and highly intuitive presentation (https://its.sdsu.edu/learning-glass/. In this technology, renamed the Learning Glass by Craig Bentley of UC San Diego, the teacher faces forward both when speaking and writing, allowing a natural interaction with both real and virtual audiences, allowing eye contact with the camera (and the virtual student). Videotaping technology simultaneously captures the instructor's face, gestures, voice, and writing. This is in contrast with conventional methods where any segments involving writing on a blackboard or whiteboard results in viewing the teacher's back for the duration. Unlike document projectors, the Learning Glass transparent whiteboard has a much larger surface area and again, allows a view of the instructor's face as the lecture progresses.

Technology accompanying the Learning Glass flips the image so that the student sees the writing as progressing from left to right, correcting the reversal that inevitably occurs when viewing writing on the reverse side of a transparent board. Depending on the specific technology, it is possible to include photos and other images in the presentation, allowing use of images more complex and professional than can be produced in real time by drawing on a whiteboard. It is also possible to set it up such that students can switch between the video feed and a PowerPoint presentation, or to record video using a live audience if that is necessary for the integrity of the presentation. For a demonstration and more thorough explanation of this technology, please watch the video at https://its.sdsu.edu/learning-glass/, produced by the inventor Matt Anderson.

How to Select a Topic for a Learning Glass Video

In selecting topics to support with a video or other online tool, we gathered feedback from students, instructional assistants, instructors, laboratory staff members, and the Education Technology Services, taking the following criteria into consideration:

1. The level of difficulty of the concept or topic.
2. How engaging current teaching on the topic was perceived to be.
3. How much instructional time it required.
4. How often the topic had to be retaught.
5. Level of difficulty in illustrating the concept on a board in real time.
6. Difficulty in progressing instruction to higher level thinking.
7. Persistence of misinformation or incomplete understanding of the concept.
8. Lack of an existing video, or existing videos were incorrect, outdated, or not sufficiently detailed.
9. Cost to lab in materials or damage to equipment as a result of incomplete understanding.

Criteria for Learning Glass

1. Topic required detailed drawings or flow charts.
2. Explanation of experiment benefited from illustration of actual variability in results.
3. High student variability in which part of the lesson needed re-explanation.
4. Topic had many layers of explanation and/or complex interlinking of concepts.
5. Advanced thought process necessary but limited by poor understanding of basics.

How to Prepare for the Video

Once a decision is made on the topics to use for a Learning Glass Video, the two most important first steps are to

1. Identify the core content areas that students need to understand. This allows prioritization of content based on cost, time limitation, or the optimal length of the video.
2. Verify that the information to be given is accurate.

Once this has been done,

3. Map out the general flow of information. Recognize that this may be different from a lecture since it is important to maintain a steady pace and to progress logically in the explanation while working on a small board area.
4. Break the information up into boards based on
    a. Amount of space on the whiteboard
    b. Logical stopping points or points for inserting assessment questions
5. Design each board: Decide intuitive and progressive placement of information or graphics. Make sure that information has room to be readable and visible.
6. Determine what graphics can easily be drawn and which need prior preparation.
7. Prepare the more complex graphics and save them as pictures.
8. If necessary set up the script for a teleprompter.

Implementation of Videos

The implementation plans for two content videos, the Kligler Iron Agar and Understanding Dilutions within the course curriculum is described below. The Kligler video illustrated a complex experiment designed to detect microbial H_2S production and to evaluate energy production from sugars and peptone through a chronological development of colors. The Dilution video walks students through the logic of dilution mathematics beginning with definitions and progressing through the most complex dilution math used in the course. The approach to implementing the dilution math video is described first.

1. *Low stakes introduction to complex concept:* Students were given a short quiz with low value or no point value. The purpose of the assignment was both to assess the baseline knowledge level and to give students advance intimation of the level of work that would be expected in the course. For the dilution math, students were given a short extra credit quiz comprising each of the main categories of dilution problems covered in the course. Points were given both for attempting all questions and for correct answers. The value of the quiz was 0.8% of the total score for the course.
2. *Brief introduction to video tools:* Students were shown brief (1-2 minutes) video clips of the appropriate video in lecture, accompanied by a description of the content.
3. *Incorporation into preparatory work:* The dilution video was divided into three segments and one or more segments were assigned as preparatory work before specific labs or lectures. Each segment was less than twenty minutes in length.
4. *Targeted teaching:* iClicker questions were used to evaluate student understanding of the concepts up to that point. Common areas of difficulty were addressed through problem solving, peer instruction, and/or teaching.
5. *Moderate stakes, non-timed self-evaluation:* Students were given one week to complete homework assignments covering the dilution math covered by the videos. After grading,

instructional assistants gave additional help to students with low performance scores.

6. *Practice in lab:* Students used the newly acquired dilution math skills in lab experiments such as the growth curve or in measuring microbial density.
7. *Repeat with more complex segments:* The cycle was repeated with increasing levels of difficulty of the math. Common areas of error highlighted by the homework assignment, by iClickers, or student questions were addressed again through problem solving with peer instruction, and conventional teaching where necessary.
8. *High stakes test*: Student mastery of the material was evaluated using a high value assessment such as a midterm or final exam.

For the Kligler Iron Agar, students were introduced to the concept using photographs of Kligler results for 3 or more organisms from 24 hour and 48 hour incubations before watching the video. Working in pairs, students were asked to describe the type and sequence of physiological processes happening in the medium. This no-credit activity served as an illustration of the level of understanding required. A sample clip introduced students to the structure and content of the of the Kligler video at http://webstage.ucsd.edu/ilti/Preview/ECON-IMVH/Biolabpromov2.1080p-crf23.mp4. This was followed by video-watching assignments, and then hands-on lab work using the same medium and a variety of microbes producing a range of physiological results. As the content became more complex, misconceptions and questions increased and were addressed through problem solving using iClickers, peer instruction, and targeted conventional teaching.

Discussion

We are in the process of designing and implementing comprehensive assessments and of evaluating the data collected through the preliminary assessments from quizzes and iClickers. Data thus far indicate that our efforts to resolve the ever-present problem of under preparedness and poor readership as well complicating issues such as language barriers and/or work and time commitments have been successful. The most obvious difference was in how teaching and learning time were redistributed to allow much more emphasis on exploring more advanced problem solving and critical thinking and less emphasis on acquiring basic information. Issues that have been alleviated by this approach are shown in Table 1.

Table 1. Summary of issues addressed by videos.

Issue	Students	Instructors
Time	To read To understand	To reteach basics For advanced thinking
Pace of learning	Individualized	Optimized
Type of learning	Understanding not memorizing	Applied Predictive Analytical
Personal interaction	Forward facing video viewed by students as more personal even when video is viewed independently outside classroom. Allows continuity of conversation with instructor	
Complexity	Deconstruction allows greater understanding of complex concepts	More effectively explore complex concepts through collaborative learning
Convenience	Each student learns at own schedule	

For preliminary evaluation of the efficacy of the videos, we compared student performance on benchmark questions. These questions test mastery of basic concepts as well as the ability to apply that knowledge to unfamiliar content. For example, students who had mastered the fundamental color changes in a Kliger iron agar as a function of physiology were tested on the evaluation of a result in which the color change was hidden but implied by an indirect result. As seen in Figure 1, iClicker data from quarters before and after implementation of the video indicates a significant increase in the level of understanding, without any additional conventional instruction.

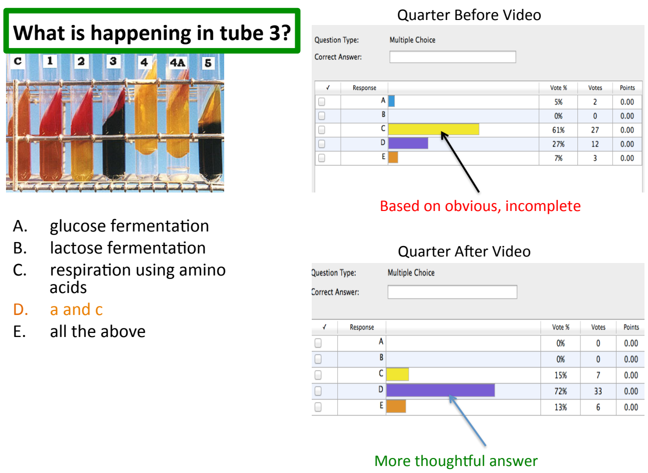

Figure 1. Comparison of student performance before and after implementation of video. The benchmark question on the Kligler iron agar presented as an iClicker question is shown to the left. The correct answer is D, while C is an incorrect answer based on visible color change but ignoring implication of color obscured by black precipitate. The panels on the right show student performance on the same question in quarters with and without the video.

Student feedback has been overwhelmingly positive, with repeated requests for more videos on other topics viewed as complex, confusing, or tedious. Other benefits of this approach include the following:

1. More time spent in discussion and less in direct teaching.
2. Weaker students gain confidence and show greater participation in peer instruction.
3. Students with learning disabilities and/or language difficulties report greater ease of learning and lesser discomfort in asking for assistance after initial viewing of videos.
4. Answers to written assessments were more organized, logical, and well supported.

The videos are available free for distribution to any academic institution.

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Learning Glass: https://its.sdsu.edu/learning-glass/

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