# Supplemental Material
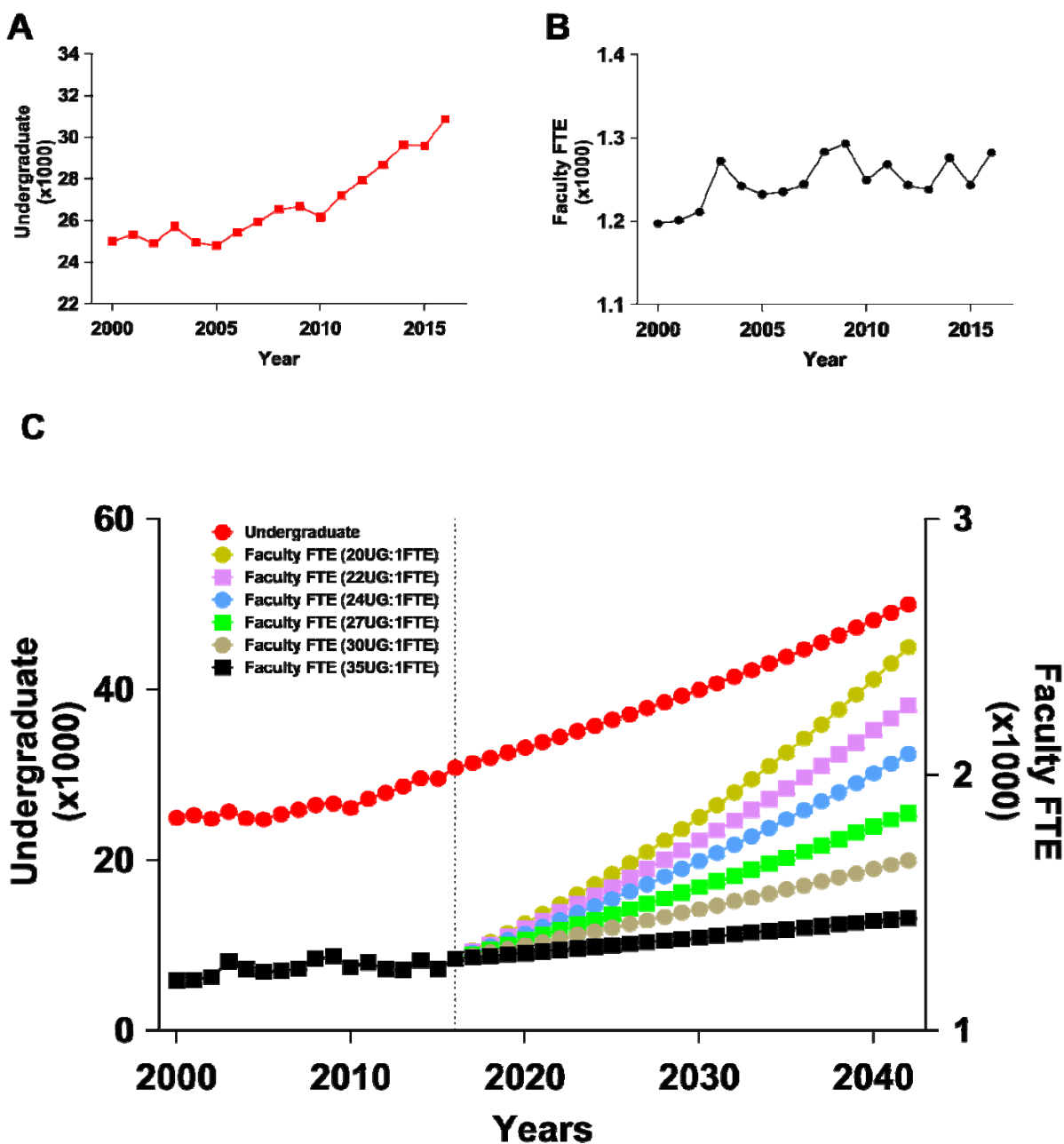
*CBE—Life Sciences Education*

Choe *et al.*

**Supplemental Figure S1. Undergraduate enrollment at UCLA reveals trends in rapid growth while faculty hires have not kept pace.**
(**A**)Annual undergraduate enrollment data is provided for the last seventeen years. A steady increase in the total undergraduate population is evident from the year 2005. In Fall 2016, the campus experienced the largest ever year-to-year increase of 1,288 undergraduates. The UCLA campus has been charged with considering strategies to increase growth to 50,000 undergraduates by the year 2042, while maintaining educational excellence. (**B**) Faculty growth

at UCLA has not kept pace with undergraduate enrollment. Annual academic ladder faculty (Full time equivalent, FTE) data is provided for the last seventeen years. The rate of growth in faculty has not kept pace with the increase in undergraduate enrollment, which has strained undergraduate to faculty ratios. In 1999-2000, the undergraduate student to faculty ratio was 21:1, which has increased to 24:1 in the 2015-2016 academic year. **(C)** Undergraduate enrollment and faculty FTE data from 1999 to 2016 are plotted. The growth rate in faculty FTE hires was determined by analyzing the data from 1999 to 2016. Projections in which the total number of undergraduates reaches 50,000 by 2042 (red circles) were modeled using the faculty growth rate determined by analyzing the trends from 1999 to 2016. Under these conditions, the undergraduate to faculty ratio will be increased to 35:1 (black squares). The faculty growth rates that would be needed to maintain more favorable undergraduate to faculty ratios, including 30:1 (beige circles), 27:1 (green squares), 24:1 (blue circles), 22:1 (purple squares), and 20:1 (green circles) are illustrated. Dashed lines mark the year 2016, which separates past data (left side) from projected data (right side).
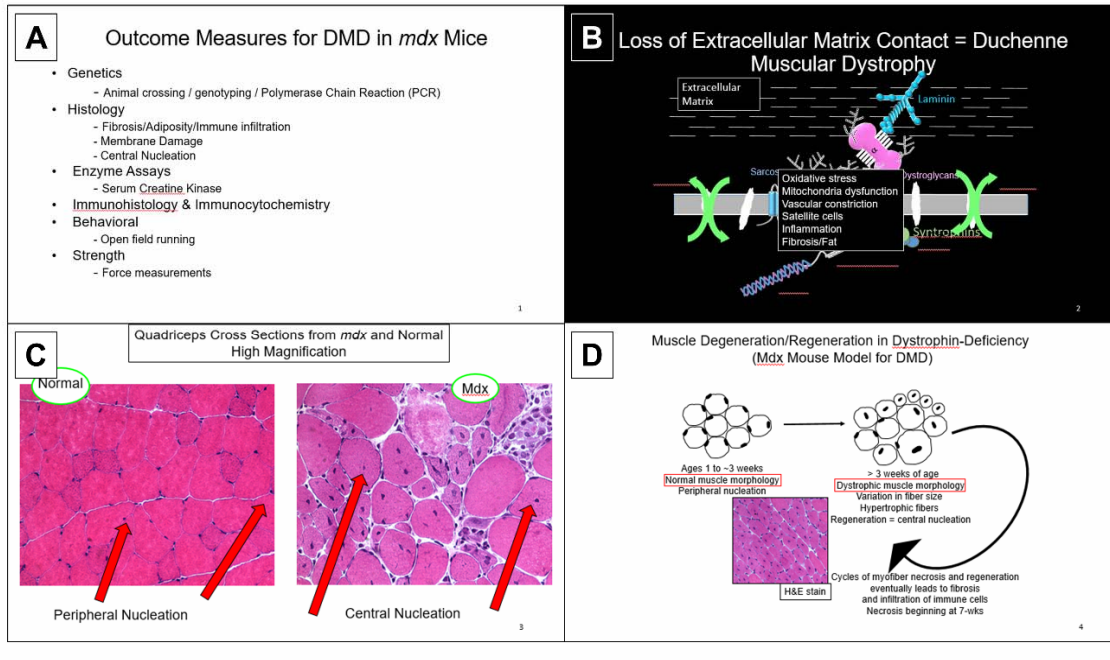
**Supplemental Figure S2. Common slide formats used to present educational content.**
Shown are four common lecture slide designs used by instructors to convey life sciences content. They include lists of terms (**A**), short animations (**B**), histological or data images (**C**), and schematic diagrams (**D**).

| Code | Individual comments | Additional items | Positive Negative | Content | Stages of Development | Role | Mayer's Multimedia Principles Overlap |
|------|---------------------|------------------|-------------------|---------|----------------------|------|---------------------------------------|
| | | | | | | | **Supplemental Table ST1. Individual codes within the Coding Online Asynchronous Lecture (COAL) protocol** |
| AA | Entertaining | Funny; Cool | Positive | User Experience | Lesson Design | Instructor | No |
| AB | Awkward; I'm uncomfortable | Silly; Fake; Who's asking questions? Feeling impersonal or disconnected | Negative | User Experience | Lesson Design | Instructor | Yes |
| AC | Familiar; similar to classroom | Similar to Bruincast | Positive | User Experience | Pre-Production | Instructor | No |
| AD | Feel personal connection with instructor | Anything that had to do with feeling normal, comfortable, in a classroom again | Positive | User Experience | Filming | Instructor | Yes |
| AE | Lack of Eye contact | | Negative | User Experience | Filming | Director | Yes |
| AF | Boring | Dry; Not exciting enough | Negative | User Experience | Pre-Production | Instructor | No |
| AG | Too much movement from speaker | | Negative | Production | Filming | Director | Yes |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| AH | Good Powerpoint use | | Positive | Screen | Lesson Design | Instructor | Yes |
| AI | Bad Powerpoint use | | Negative | Screen | Lesson Design | Instructor | Yes |
| AJ | Good Pacing | Easy to follow, Good organization | Positive | Speaker | Filming | Instructor | Yes |
| AK | Too Fast | Talks too fast | Negative | Speaker | Filming | Instructor | Yes |
| AL | I like the critical Thinking and problem solving | | Positive | Pedagogy | Lesson Design | Instructor | No |
| AM | High learning value | | Positive | Pedagogy | Lesson Design | Instructor | Yes |
| AN | Engaging | Interesting | Positive | User Experience | Lesson Design | Instructor | Yes |
| AO | Should be added as a supplement | Should be included in combination | Positive | Pedagogy | Pre-Production | Instructor | No |
| AP | Not enough material | Not enough text; Not enough detail | Negative | Pedagogy | Lesson Design | Instructor | Yes |
| AQ | Good detail | | Positive | Pedagogy | Lesson Design | Instructor | Yes |
| AR | Distracting | Hard to focus; confusing | Negative | Production | Filming | Director | Yes |
| AS | Interactive | | Positive | Pedagogy | Filming | Instructor | Yes |
| AT | Not interactive enough | | Negative | Pedagogy | Filming | Instructor | Yes |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| AU | Please make it more similar to Khan Academy | | Negative | Production | Pre-Production | Instructor/ Director | Yes |
| AV | Similar to Khan Academy | | Positive | Production | Pre-Production | Instructor/ Director | Yes |
| AW | I like Drawings/animations | I like chalkboard | Positive | Screen | Lesson Design | Instructor | Yes |
| AX | Question and answers | | Positive | Pedagogy | Lesson Design | Instructor | No |
| AY | Unable to take notes along with instructor | | Negative | Pedagogy | Lesson Design | Instructor | Yes |
| AZ | Able to take notes along with instructor | | Positive | Pedagogy | Lesson Design | Instructor | Yes |
| BA | Emphasize what is important | Simple; Straight to the point | Positive | Pedagogy | Lesson Design | Instructor | Yes |
| BB | Good overall quality of video | Generally good comment about video | Positive | Screen | Post-Production | Director | No |
| BC | Bad overall quality of video | Generally bad comment about video | Negative | Screen | Post-Production | Director | No |
| BD | Instructor's performance on camera is good | good lecturer | Positive | Speaker | Lesson Design | Instructor/ Director | Yes |
| BE | Prefer other styles | worse than other styles | Negative | Screen | Pre-Production | Instructor/ Director | No |
| BF | Favorite style | better than other styles | Positive | Screen | Pre-Production | Instructor/ Director | No |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BG | Glasses are distracting | Clothes are distracting | Negative | Speaker | Filming | Director | Yes |
| BH | Don't point with glasses | use laser pointer; not good pointing; don't know what she's pointing at; Just underlining | Negative | Speaker | Filming | Director | Yes |
| BI | Color choice for pointing inappropriate | background color inappropriate | Negative | Screen | Pre-Production | Director | Yes |
| BJ | Instructor blocking the slide | Can't see material | Negative | Screen | Pre-Production | Director | Yes |
| BK | Difficult to focus on both instructor and slide | | Negative | Screen | Pre-Production | Director | Yes |
| BL | Camera movement and focus is bad | Too much movement | Negative | Screen | Filming | Director | Yes |
| BM | Needs more visuals | Needs more animations | Negative | Screen | Lesson Design | Instructor | Yes |
| BN | Focus should be on the material, not instructor | Instructor doesn't need to be on screen | Negative | Screen | Filming | Director | Yes |
| BO | Too much text | | Negative | Screen | Lesson Design | Instructor | Yes |
| BP | Slide information too small | Slide information not clear; hard to read | Negative | Screen | Post-Production | Director | Yes |
| BQ | No comment | | Negative | | | | No |

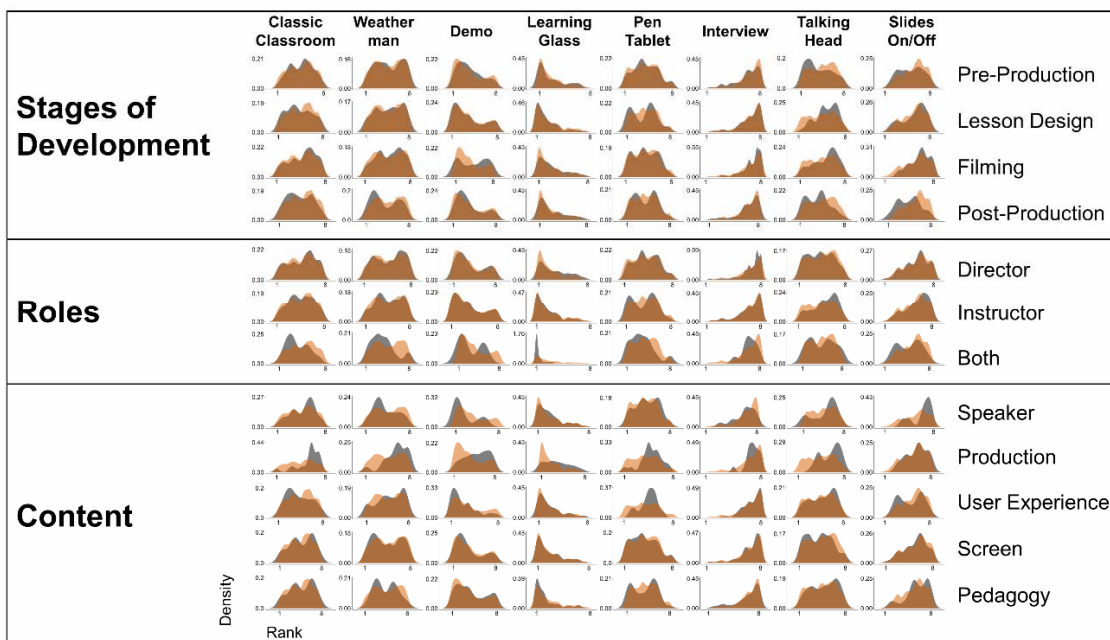| | | | | | | | |
|---|---|---|---|---|---|---|---|
| BR | I liked the extra focus on material | Easier to see material; slide always visible | Positive | Screen | Post-Production | Director | Yes |
| BS | Too slow | Too long; | Negative | Speaker | Filming | Instructor | Yes |
| BT | Want to watch at my own pace | Wish there was a pause button | Negative | Production | Pre-Production | Director | Yes |
| BU | Not as distracting | Easier to focus | Positive | User Experience | Filming | Director | Yes |
| BV | Not engaging | | Negative | User Experience | Lesson Design | Instructor | No |
| BW | I like Real world application | Relatable | Positive | Pedagogy | Lesson Design | Instructor | No |
| BX | I want a copy of lecture slides | | Negative | Pedagogy | Post-Production | Instructor | Yes |
| BY | No Learning value | | Negative | Pedagogy | Lesson Design | Instructor | Yes |
| BZ | Bad instructor's performance on camera | | Negative | Speaker | Filming | Director | Yes |
| CA | Camera movement and focus was good | Variety of shots is good, looks good | Positive | Screen | Filming | Director | Yes |
| CB | Uncategorized | | Negative | | | | No |
| CC | Want to see instructor | | Negative | Screen | Filming | Director | Yes |
| CD | Don't like chalkboard | | Negative | Screen | Filming | Instructor | Yes |
| CE | Need to include subtitles | | Negative | Screen | Post-Production | Director | No |

| | | | | | | | |
|------|------------------------------------|-------------------------------|----------|-------------------|-----------------|------------------------|------|
| CF | Too much material | | Negative | Pedagogy | Lesson Design | Instructor | Yes |
| CG | Talks too fast | too much talking | Negative | Speaker | Filming | Instructor | Yes |
| CH | Direct pointing good | | Positive | Screen | Filming | Instructor/ Director | Yes |
| CI | Not enough chalkboard/drawing | | Negative | Pedagogy | Lesson Design | Instructor | Yes |
| CJ | Good eye contact | | Positive | Speaker | Filming | Instructor | Yes |
| CK | Stable camera | Less movement | Positive | Screen | Filming | Director | Yes |
| CL | Good able to see both speaker and material | | Positive | Screen | Pre-Production | Director | Yes |
| CM | Similar to other styles | | Negative | Production | Pre-Production | Instructor/ Director | No |
| CN | Slides are nice and big | Text nice and big and visible | Positive | Screen | Post-Production | Director | Yes |
| CO | Unfamiliar | | Negative | User Experience | Pre-Production | Instructor | Yes |
| CP | Will not work with all material | Too simple | Negative | Production | Pre-Production | Instructor | No |
| CQ | Rank related from question 9 | | Negative | | | | No |

**Supplemental TableST1. Individual codes within the Coding Online Asynchronous Lecture(COAL) protocol.**
Summary of coding categories and subcategories with relevant descriptions of each code. Identifying codes were created with a bijective numbering scheme. Common phrases that were used to identify comment contents are listed in the items and additional items columns. The positive and negative columns indicate whether the code was considered a positive or negative comment (1=True, 0=False). The subsequent columns (Content, Developmental Stage, Role)

indicate the subcategory assigned to each comment. The students' survey comments were codes were tabulated manually.

**Supplemental Figure S3. Category controls for density distribution analysis.**
Comparisons of rank kernel density distributions of each video style within the subcategories with the average kernel density distributions for each subcategory. The density overlay for each style is shaded in grey and the average for the subcategory is shaded in orange. This overlay visualizes deviations from the category average. Ranks are on the X-axis ranging from 1-8, with ties being averaged. The probability density functions with kernel smoothing are on the Y-axis. Plots created with R software.

**Supplemental Figure S4. Style controls for density distribution analysis.**
Comparisons of rank kernel density distributions of each video style within the subcategories with the average kernel density distributions for each subcategory. The density overlay for each style is shaded in grey and the average for the style is shaded in orange. This overlay visualizes deviations from the style average. Ranks are on the X-axis ranging from 1-8, with ties being averaged. The probability density functions with kernel smoothing are on the Y-axis. Plots created with R software.

| Supplemental Table ST2. Summary of strengths and weaknesses of video styles. | | |
|---|---|---|
| **Video Style** | **Strengths** | **Weaknesses** |
| **Classic Classroom** | Familiar, chalkboard drawings, animations in lecture slides, professional video quality | Distracting camera movement, hard to see where instructor is pointing, not engaging format |
| **Weatherman** | Slide content visible, good focus on instructor, professional video quality | Instructor blocks material, hard to see where instructor is pointing, format seems awkward, distracting |
| **Demo** | Engaging, entertaining, high learning value, professional quality video | Not enough content in demo to replace lecture, should only be used as supplement to lecture |
| **Learning Glass** | Drawings are good, entertaining, strong engagement with material, able to take notes while watching, good pace, good connection and interaction with instructor, high learning value, professional quality video | Pace too slow, instructor's position interferes with visibility of material, distracting |
| **Pen Tablet** | Good drawings, animations, similar to chalkboard, good lesson design | Bad color choice for pen, instructor blocks material, hard to see where instructor is pointing, |
| **Interview** | Q&A format is helpful | Awkward format, low learning value, should be used as supplement to lecture |
| **Talking Head** | Material is visible, able to see both instructor and content, good overall quality | Talking head blocking content, not engaging, too much camera movement |
| **Slides On/Off** | Good overall quality | Distracting camera movement between instructor and material, decreased visibility of lecture slides when focusing only on instructor |

**Supplemental Table ST2. Summary of strengths and weaknesses of video styles.**
The table summarizes comments from student surveys regarding eight common video styles used in online and hybrid courses.
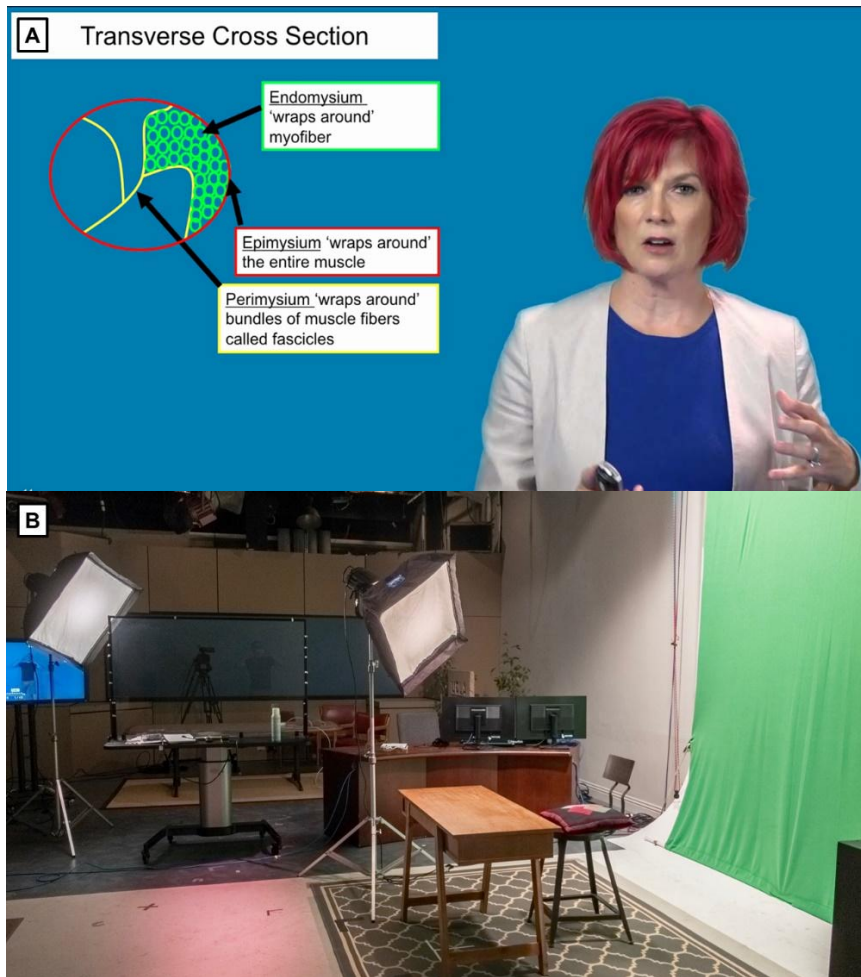
**Supplemental Figure S5. Lecture style and recording studio design determined by best practices identified in this study.**
(**A**) The image shown is a screenshot of the final video style that was chosen for an online course. It shows the instructor speaking in front of a green screen and the lecture materials composited into the background. Students can visualize the content while simultaneously engaging with the instructor. (**B**) The image shown is a picture of the final recording studio stage setup where the instructor was positioned during filming of lecture videos.

**Supplemental Movie SM1. Classic Classroom video style used for survey and learning outcomes.** The video can be viewed at the following link (password: coal):
https://ucla.box.com/v/SSLO-supplemental-movie-sm1

**Supplemental Movie SM2. Weatherman video style used for survey and learning outcomes.** The video can be viewed at the following link (password: coal):
https://ucla.box.com/v/SSLO-supplemental-movie-sm2

**Supplemental Movie SM3. Demo video style used for survey and learning outcomes.** The video can be viewed at the following link (password: coal):
https://ucla.box.com/v/SSLO-supplemental-movie-sm3

**Supplemental Movie SM4. Learning Glass video style used for survey and learning outcomes.** The video can be viewed at the following link (password: coal): https://ucla.box.com/v/SSLO-supplemental-movie-sm4

**Supplemental Movie SM5. Pen Tablet video style used for survey and learning outcomes.** The video can be viewed at the following link (password: coal): https://ucla.box.com/v/SSLO-supplemental-movie-sm5

**Supplemental Movie SM6. Interview video style used for survey and learning outcomes.** The video can be viewed at the following link (password: coal): https://ucla.box.com/v/SSLO-supplemental-movie-sm6

**Supplemental Movie SM7. Talking Head video style used for survey and learning outcomes.** The video can be viewed at the following link (password: coal): https://ucla.box.com/v/SSLO-supplemental-movie-sm7

**Supplemental Movie SM8. Slides On Off video style used for survey and learning outcomes**. The video can be viewed at the following link (password: coal): https://ucla.box.com/v/SSLO-supplemental-movie-sm8

**Supplemental Movie SM9. Final video style following best practices.** The video can be viewed at the following link (password: coal): https://ucla.box.com/v/SSLO-supplemental-movie-sm9