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Using Presentation Software To Flip an Undergraduate Analytical Chemistry Course

Neil Fitzgerald*,† and Luisa Li‡

†Department of Chemistry, Biochemistry and Physics and ‡Academic Technology, Marist College, Poughkeepsie, New York 12601, United States

ABSTRACT: An undergraduate analytical chemistry course has been adapted to a flipped course format. Course content was provided by video clips, text, graphics, audio, and simple animations organized as concept maps using the cloud-based presentation platform, Prezi. The advantages of using Prezi to present course content in a flipped course format are discussed. Results of an American Chemical Society analytical chemistry examination were encouraging. Results of pre- and postsurveys of student perception of their learning are summarized.

KEYWORDS: *Upper-Division Undergraduate, Analytical Chemistry, Collaborative/Cooperative Learning, Computer-Based Learning, Problem Solving/Decision Making*

INTRODUCTION

The flipped or inverted class is a pedagogical concept characterized by the typical classroom activity of content delivery being performed by students on their own time and more active problem-solving activities, which might traditionally be assigned as homework, being conducted during class time. Proponents argue that this approach is more effective at achieving course objectives. Advantages identified by Kathleen Fulton[1] are that students cover content at their own pace; teachers gain a better insight into students' learning styles and difficulties; instructors can more easily customize and update the curriculum; classroom time can be used more effectively and creatively; students' level of interest, engagement, and enthusiasm are seen to increase; learning theory supports the new approaches; and the use of technology is flexible and appropriate for 21st century learning. Herreid and Schiller[2] added several other advantages including that the method promotes thinking inside and outside the classroom, students are more actively involved, and students like it.

Student learning outcome enhancements have been reported. Hamdan et al.[3] reviewed the educational aspects of flipped learning. They highlighted work by Papadopoulos and Roman,[4] who reported a significant increase in student performance in an undergraduate electrical engineering course compared to a control group. Warter-Perez and Dong[5] found that the flipped course appeared effective in a freshman and sophomore level digital engineering course and was supported by students. Bishop and Verleger[6] reviewed research into the flipped classroom model. They found 24 studies related to the flipped classroom reported through June 2012. Student opinions of the approach in these studies tended to be positive. Few of the studies provided quantitative data on student performance. Moravec et al.[7] performed what Bishop and Verleger describe as a "partial flip" (i.e., they still provided some in-class lecturing) for three lectures in an introductory biology course. They reported a performance increase of 21% on exam questions related to the topics introduced outside of class. McLaughlin et al.[8] flipped a pharmaceutics course using recorded course lectures available on a Web site. Survey results showed that students preferred the format and felt that it enhanced their learning although final examination performance did not differ significantly from the previous year. Examples of flipped learning in chemistry courses in the literature are rare. Bergan and Sams[9] reported the use of flipped learning in a high school chemistry course using vodcasts (video podcasts). Baker[10] has flipped a college General Chemistry course using video with embedded questions. The flipped course format has also been reported as a successful approach for a university organic chemistry class[11] and advanced placement chemistry high school students.[12]

Although the flipped class concept is not new, technological advances have led to an increased interest in STEM fields over the past couple of years. The majority of flipped courses use online videos to provide course content. Some instructors use pre-existing videos (e.g., from the Khan Academy[13]) available online from services such as YouTube, while some spend the time to make their own. Other modalities include combining video with quizzes, podcasts, and computer modules. He et al.[14] reported on the use of video tutorials in an analytical chemistry course and concluded that they were "a valuable, flexible, and

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cost-effective tool to improve student mastery of chemical problem solving." Revell recently described the use of new technologies in an introductory chemistry course and found that a combination of technologies "appears to have a positive impact on retention compared with previous semesters."[15]

In this work we describe the application of a flipped course approach to an undergraduate analytical chemistry course incorporating the use of the Prezi presentation platform. Analytical chemistry is inherently a problem-solving subject and lends itself well to this format. Prezi is a freely available online presentation tool that seems ideal for organizing course content in an interactive, flexible, and visually attractive manner while allowing the instructor to demonstrate linkage between course content graphically. Its functions are similar to those of graphic knowledge representation tools such as Vee diagrams and Concept maps.[16,17] Both Vee diagrams and concept maps have been used and studied extensively in chemistry education and have proven effective in some cases.[18−20] In this study we pose the question, can Prezi effectively facilitate the flipped class approach?

METHODS

Course Description

CHEM355 is a junior level undergraduate analytical chemistry course. The course serves as a basic introduction to analytical chemistry incorporating instrumental and noninstrumental methods, statistics, sampling and sample pretreatment, and calibration methods. The course is required for all chemistry and biochemistry majors and can also be used for other majors wishing to obtain the chemistry minor. Enrollment has ranged from 8 to 14 students between fall 2009 and fall 2013. The course meets weekly for two 1 h 15 min periods and one 2 h 45 min laboratory period.

Course Approach

The general approach for a flipped course is to require the student to learn content outside the classroom, leaving classroom time for problem-solving activities. A comparison of the new course format to the traditional format is show in Figure 1. In the flipped format the course content was provided

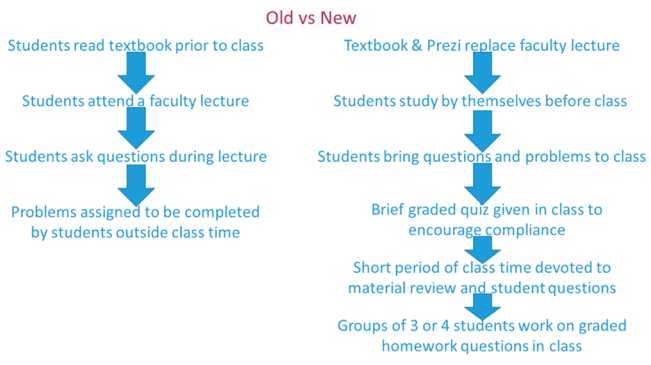

Figure 1. Comparison of the traditional format to the flipped format of the course.

by a series of online presentations developed using the Prezi platform. The presentations and associated resources are freely available to the general public via the Analytical Sciences Digital Library.[21] Prezi is a cloud-based presentation and storytelling tool for displaying ideas on a virtual canvas. It employs a Zooming User Interface (ZUI) allowing the user to zoom in and out of the canvas to give a 3D experience. In education Prezi has been shown to facilitate different learning styles and allow complex ideas to be presented.[22] The presentations can include text, graphics, simple animation, video, and audio. In this course videos were produced using Camtasia or Screen-Chomp and uploaded to YouTube prior to incorporating into Prezi. Video clips were generally around 5 min long, in keeping with best practice, which recommends videos shorter than 6 min to avoid high dropout rates (students stopping the video before the end).[23,24] Some examples of Prezi usage in this course include the following.

- A Prezi for each chapter of the text.
- A short introductory video to provide an overview of each chapter. This mirrors lecture, in which the instructor typically spends a minute or two introducing the subject and providing some context.
- Utilizing the ZUI to demonstrate nested concepts, e.g., clicking on a box labeled "protocol" zooms to a "procedure" box, which in turn zooms to "method' and "technique", demonstrating the relationship between the terms. This approach helps demonstrate relationships between concepts.
- Student self-testing. By providing a question with the answer hidden in the background, students have the opportunity to answer the question before the answer is revealed. This mirrors the class exercise of asking questions during lecture.
- Simple animations to illustrate terms, e.g., photos of equipment with labels that become visible sequentially. These guide the students through the material and avoid overwhelming them with information.
- Brief audio clips to emphasize important concepts.
- Short videos of worked problems. These are typically about 5 min long and viewed frequently by students to help them answer the graded problems.
- Equations or videos linked to a summarizing graphic, e.g., different points on a titration curve linked to videos demonstrating how to calculate the pH at each point. This approach allows students to see how a calculation fits into the overall concept.

Prezi also has the advantage of being visually appealing and allowing material to be organized graphically. Each Prezi includes a series of linked modules. For example, Figure 2 is a graphical representation of a Prezi covering the topic of spectroscopy. After introducing basic theory, the areas of spectroscopy are broken down into separate modules based on interaction type (absorption, emission, and scattering) with each specific technique linked as a separate module to an interaction type. Each module may include text, images, videos, and audio clip components which can be accessed by clicking directly on the component. Alternatively, the components may be viewed in a preassigned order by clicking the advance icon. The concept map approach allows students to understand relationships between seemingly unrelated techniques, e.g., infrared and flame atomic absorption spectrometry, and creates a visual aid to remembering material. Prezi also allows students to "dip into" the material at any point by clicking on the part of canvas that they wish to view. Prezi is compatible with most Web browsers with the Abobe Flash plugin. An app is also available for iPad and iPhone allowing students to use smart phones and tablets if they do not have easy access to a computer.

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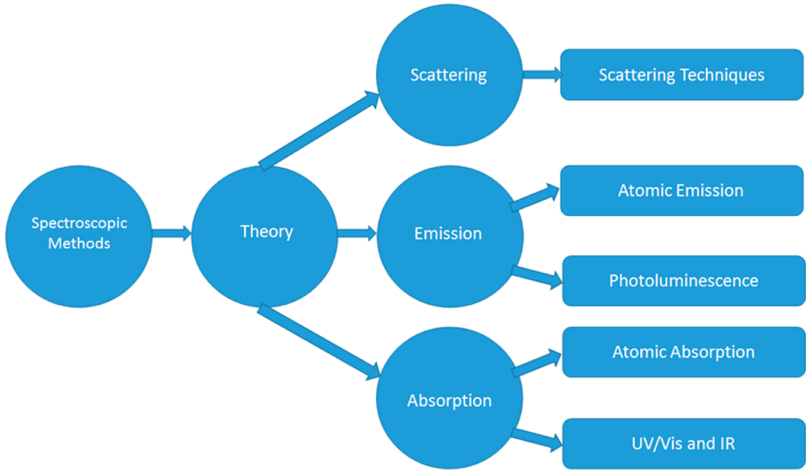

Figure 2. Graphical representation of a Prezi covering the topic of spectroscopy in CHEM355: Analytical Chemistry.

Figure 3. ACS analytical chemistry examination results by year.

Compliance with the Prezi assignment was assessed by incorporation of a short (approximately 10 min) graded multiple choice quiz using classroom response system "clickers" given at the beginning of each class period. After a short question and answer session, students worked in groups of three or four to solve assigned questions from an online homework system (Sapling Learning). The laboratory component of the course remained unchanged.

Assessment Methods

The course approach was assessed by student performance on the ACS analytical chemistry examination (Analytical Chemistry, Form 2007, Examinations Institute of the American Chemical Society, University of Wisconsin, Milwaukee, WI), student response to the college student evaluation form, and results of pre- and postsurveys (Field-tested Learning Assessment Guide MC^2/ChemLinks) used with IRB approval. These surveys are designed to assess students' experiences in chemistry classes, including their interest and engagement and the effect of course organization and teaching on their thinking and learning experiences.[25]

Student achievement of learning goals were assessed by in-class examinations, the ACS analytical chemistry examination, performance on Web-based "homework", and performance in laboratory-based activities.

RESULTS AND DISCUSSION

Performance on the ACS analytical chemistry examination is shown in Figure 3. Over the past five years several modifications to the course have been made in order to improve performance including the incorporation of classroom response system questions in 2011 and Web-based homework questions in 2012. A common criticism to Web-based homework was that the students felt they were not provided sufficient guidance to complete the assignments. The flipped course approach was implemented partly in response to these comments. Although student numbers are too small to be statistically significant (one-way ANOVA, 95% confidence), ACS scores do show an improvement. Performance in written examinations and student GPAs were not significantly different from year to year.

Student written responses on anonymous course evaluations were overwhelmingly positive. Students stated that group work on problems during class time was helpful and allowed more opportunity to ask questions. Several students commented that they enjoyed the style of the class and the presentation of course material on Prezi. The pre- and postcourse surveys consisted of 47 and 74 questions respectively in which students were asked to provide responses using a five point Likert scale. Given the low number of responses, only questions that appear in both surveys resulting in a change in the mode response were

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considered (Table 1). The suggestions from the survey results are that the approach de-emphasized the textbook and gave students the impression that computer-based materials have a positive effect on their learning, an expected result given the emphasis on computer-based materials. Students feel less need for outside help probably due to the increased interaction between student and the instructor and between peers in the classroom setting. This may have also resulted in reducing the impression that they learn best individually.

Table 1. Responses to Selected Survey Questions

Statements for Student Response	Precourse (Mode Response, N = 13)	Postcourse (Mode Response, N = 11)
I learn well by...		
Using computer-based materials	Agree	Strongly agree
Reading a (good) textbook	Agree	Neutral
Getting good help/tutorial aid	Agree	Neutral
Reading and rereading materials	Strongly agree	Agree
Working on my own	Strong agree	Agree

CONCLUSIONS AND IMPLICATIONS

Prezi provides a convenient and attractive method to organize and present material in a flipped course format and is popular with students based on student comments. The course instructor is encouraged by this initial experiment and plans to repeat the course without modification. A major advantage of the flipped course approach was the positive response from students who were able to receive more help with the challenging problems. Although developing the course Prezi materials and associated videos was a major time commitment, the advantages to student learning (in the view of the instructor) of providing a visual and flexible approach to learning, demonstrating concept linkages, and demonstrating problem solving using embedded video clips were significant and were worth the initial effort. It is hoped that the available Prezi materials and our initial results will encourage others to try this approach.

AUTHOR INFORMATION

Corresponding Author

*E-mail: neil.fitzgerald@marist.edu.

Notes

The authors declare no competing financial interest.

REFERENCES

(1) Fulton, K. Upside down and inside out: Flip your Classroom to Improve Student Learning. *Learn. Leading Technol.* **2012**, *39* (8), 12–17.

(2) Herreid, C.; Schiller, N. Case Studies and the Flipped Classroom. *J. Coll. Sci. Teach.* **2013**, *42* (5), 62–66.

(3) Hamdan, N.; McKnight. K.; Arfstrom, K. *A Review of Flipped Learning*; Flipped Learning Network: 2013.

(4) Papadapoulos, C.; Roman, A. S. *Implementing an Inverted Classroom Model in Engineering Statistics: Initial Results*. Proceedings of the 40th ASEE/IEEE Frontiers in Education Conference, Washington, DC, Oct 2010.

(5) Warter-Perez, N.; Dong, J. *Flipping the Classroom: How to Embed Inquiry and Design Projects into a Digital Engineering Lecture*. Proceedings of the 2012 ASEE PSW Section Conference, California Polytechnic State University, San Luis Obispo, April 2012.

(6) Bishop, J. L.; Verleger, M. A. *The Flipped Classroom: A Survey of the Research*. 120th ASEE Annual Conference & Exposition, Atlanta, GA, June 23–26, 2013.

(7) Moravec, M.; Williams, A.; Aguilar-Roca, N.; O'Dowd, D. K. Learn before Lecture; A Strategy That Improves Learning Outcomes in a Large Introductory Biology Class. *CBE Life Sci. Edu.* **2010**, *9* (4), 473–481.

(8) McLaughlin, J. E.; Griffin, L. M.; Esserman, D. A.; Davidson, C. A.; Glatt, D. M.; Roth, M. T.; Gharkholonarehe, N.; Mumper, R. J. Pharmacy Student Engagement, Performance, and Perception in a Flipped Satellite Classroom. *Am. J. Pharm. Educ.* **2013**, *77* (9), 196.

(9) Bergmann, J.; Sams, A. Remixing Chemistry Class. *Learn. Leading Tech.* **2008/2009** (Dec/Jan), 22–26.

(10) Baker, J. *Lesson from the First-Time Flip: Tips, Observations and Assessment from the Implementation of the Inverted-Classroom Model in General Chemistry*. PITTCON 2014, Chicago, IL, March 2–6, 2014.

(11) Christiansen, M. Inverted Teaching: Applying a New Pedagogy to a University Organic Chemistry Class. *J. Chem. Educ.* **2014**, *91* (11), 1845–1850.

(12) Schultz, D.; Duffield, S.; Rasmussen, S.; Wageman, J. Effects of the Flipped Classroom Model on Student Performance for Advanced Placement High School Chemistry Students. *J. Chem. Educ.* **2014**, *91* (9), 1334–1339.

(13) Khan Academy. https://www.khanacademy.org/ (accessed June 10, 2014).

(14) He, Y.; Swenson, S.; Lents, N. Online Video Tutorials Increase Learning of Difficult Concepts in an Undergraduate Analytical Chemistry Course. *J. Chem. Educ.* **2012**, *89* (9), 1128–1132.

(15) Revell, K. A Comparison of the Usage of Tablet PC, Lecture Capture, and Online Homework in an Introductory Chemistry Course. *J. Chem. Educ.* **2014**, *91* (1), 48–51.

(16) Jonassen, D. H. Tools for representing problems and the knowledge required to solve them. In *Knowledge and Information Visualization*; Tergan, S. O., Keller, T., Eds.; Springer: Berlin, 2005; pp 82–94.

(17) Novak, J. D.; Cañas, A. J. *The Theory Underlying Concept Maps and How to Construct Them*; Technical Report for Florida Institute for Human and Machine Cognition: Pensacola, FL, 2008. http://cmap.ihmc.us/publications/ResearchPapers/TheoryCmaps/TheoryUnderlyingConceptMaps.htm (accessed Aug 11, 2014).

(18) Kilic, M.; Cakmak, M. Concept Maps as a Tool for Meaningful Learning and Teaching in Chemistry Education. *Int. J. New Trends Educ. Their Implic.* **2013**, *4* (4), 152–164.

(19) Markow, P. G.; Lonning, R. A. Usefulness of Concept Maps in College Chemistry Laboratories: Students' Perceptions and Effects on Achievement. *J. Res. Sci. Teach.* **1998**, *35* (9), 1015–1029.

(20) Polancos, D. T. Effects of Vee Diagram and Concept Mapping on the Achievement of Students in Chemistry. *Liceo J. Higher Educ. Res.* **2011**, *7* (1), 18–38.

(21) Fitzgerald, N.; Li, L. CHEM355-A Flipped Analytical Chemistry Course *Journal of the Analytical Sciences Digital Library* [online] **2013**. http://jasdl.asdlib.org/2013/11/chem355-a-flipped-analytical-chemistry-course/ (accessed June 10, 2014).

(22) Virtanen, P.; Myllarniemi, J.; Wallander, H. Diversifying Higher Education: Innovative Tools to Facilitate Different Ways of learning. *Int. Conf. Inf. Commun. Technol. Educ.* **2012**, 105–116.

(23) Kim, J.; Guo, P. J.; Seaton, D. T.; Mitros, P.; Gajos, K. Z.; Miller, R. C. *Understanding In-Video Dropouts and Interaction Peaks in Online Lecture Videos*. ACM Conference on Learning at Scale, Atlanta, GA, March 4–5, 2014.

(24) Guo, P. J.; Kim, J.; Rubin, R. *How Video Production Affects Student Engagement: An Empirical Study of MOOC Videos*. ACM Conference on Learning at Scale, Atlanta, GA, March 4–5, 2014.

DOI: 10.1021/ed500667c
J. Chem. Educ. XXXX, XXX, XXX–XXX

(25) Field-tested Learning Assessment Guide for Science, Math, Engineering, and Technology Instructors. http://www.flaguide.org (assessed June 10, 2014).

DOI: 10.1021/ed500667c
J. Chem. Educ. XXXX, XXX, XXX−XXX