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Activity

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# Eliciting Student Explanations of Experimental Results Using an Online Discussion Board

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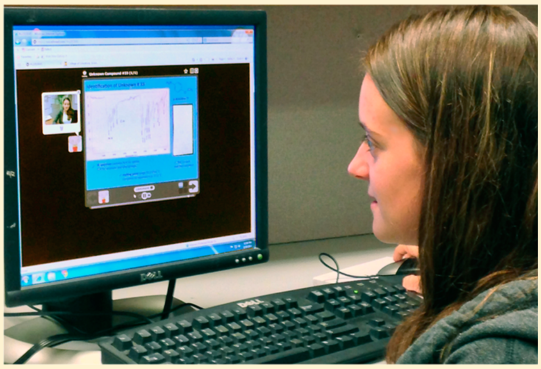
S *Supporting Information*

**ABSTRACT:** An online discussion is used to engage students in data interpretation and analysis in an introductory organic chemistry laboratory course. Students post an audio or video recording to explain their problem-solving processes and to provide interpretation of laboratory data. The discussion board (VoiceThread) features a drawing tool that also supports the inclusion of images and graphical representations of data. The activities described are broadly applicable to any science discipline and are particularly useful in high-enrollment classes where opportunities for students to practice data interpretation and discussion of lab results may be limited.



**KEYWORDS:** *Second-Year Undergraduate, Organic Chemistry, Laboratory Instruction, Safety, Communication, Computer-Based Learning, IR spectroscopy, Thin Layer Chromatography*

Providing students with the opportunity for reflective thinking about their experimental results is a persistent challenge in high-enrollment undergraduate laboratory courses.[1−3] Ideally, a faculty laboratory instructor has the time to wander the room, engaging each student in a dialogue about what is happening and why. Unfortunately, this is often not a deliberate practice,[4] and it becomes functionally impossible if a faculty instructor is managing multiple sections with hundreds of students.

Both writing-to-learn[5] and talking-to-learn[6] methods require students to explain, elaborate, and defend their ideas, which are activities that facilitate knowledge construction and help students to develop deep understanding.[7] Thus, pedagogies based on creative activities of this sort offer an opportunity to capture a rich sample of student thinking for both research and instructional purposes when it might otherwise be impractical. Recent strategies by which students can practice written or spoken explanations via online activities include wiki sites,[8,9] Web pages,[10] videos,[11] and pencasts.[12] In this paper, the use of an online platform is reported to promote students' explanations of laboratory data and results.

## ■ ONLINE PLATFORM

The activities described here are facilitated using VoiceThread,[13] an asynchronous online discussion board, on which students can respond to instructor prompts using video or audio tools. Among the possible platforms with similar capability,[14,15] VoiceThread was selected for its ease of use, ability to integrate multiple media sources, and availability (an inexpensive site license is available for individual instructors). It also utilizes a drawing tool that allows assignments to be coupled with strong visual elements, such as reaction schemes, spectroscopic data, photographs of thin-layer chromatography plates or other objects from lab, or 3D animations of molecules.

A core feature of representational competence is understanding which representations to use, and when, during an explanation.[16] A strong connection between the visual and verbal components of an activity are important when technology is used to teach chemistry, as online visual teaching tools are most effective when coupled with a "reflective feature" to encourage explanation.[17] VoiceThread supports an explicit connection between the visual elements and dialogue because when using the drawing tool, students may interact with an image concurrently with their recorded response.

VoiceThread facilitates interactive learning because students can view and respond to each other's assignments and posts. They indirectly teach each other through the process of writing up their work and reading that of others. Peer interaction can be informal and voluntary or can be moderated by the instructor through assignment requirements. VoiceThread also enables valuable communication between students and instructors. An instructor can easily view a representative sample of student responses through a single interface, which is convenient with a large number of student participants. Student work provides a rich data source for formative assessment because these posts are essentially the same as carrying out "think-aloud" sessions. Instructors may utilize example posts in lecture to address errors, incomplete understanding, or logical inconsistencies in a way that de-emphasizes the right-andwrong of grading and focuses listeners more on the thinking process.

## ■ DISCUSSION-BASED ACTIVITIES

Four assignments designed for use with VoiceThread are the following. For each activity, an example slide prompt was generated on the system along with associated video explanation of the assignment. In response, students had one week to upload their own slides, which they tagged onto the end of the instructor prompt and explained using the audio or video tools on the site. The instructor viewed and commented on a random sample of students' slides and identified example assignments for subsequent discussion in lecture. Finally, students participated in a peer critique process that was also facilitated through the system. Specific grading rubrics were developed for each activity and are included in the Supporting Information.

### Visual Identification of Safety Hazards

Safety is an ideal topic for online discussion because students should learn to identify the hazards they might encounter in the lab. In this assignment, student discussion of safety is elicited by a series of photographs in which students are depicted engaging in various unsafe practices (Figure 1). In their posts, students

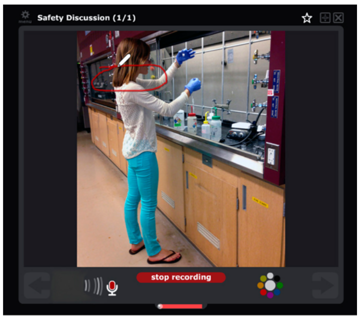



**Figure 1.** Screenshot of an example safety discussion in which a student used the drawing tool to circle the eye area to indicate that the subject's hair was not properly tied back.

are required to (1) identify three or more safety hazards; (2) describe why each was a hazard; and (3) indicate the proper safety method or protocol. The grading rubric requires correct identification of hazards with a corresponding comment on how each hazard can be remediated.

### "Thin-Layer Chromatography Is Like Quidditch"

Metaphor is a powerful pedagogical strategy that helps students to make connections to prior knowledge and thus makes abstract concepts more concrete.[18] In this assignment students design a metaphor to describe thin-layer chromatography (TLC) and prepare a slide to depict their metaphor visually (Figure 2). Students posted imaginative metaphors comparing TLC to snow skiing, dating, or Quidditch (from the Harry Potter series).[19] In an example metaphor, one student compared TLC to Quidditch where the "seeker" is likened to a nonpolar molecule, because they "try to interact as little as possible with the other players". The grading rubric looks for a thorough explanation of each aspect of the metaphor as it connects to TLC and the accuracy of information.

### Interpretation of Infrared Spectra

Students routinely practice spectral interpretation through homework, but are not often called on to discuss or explain

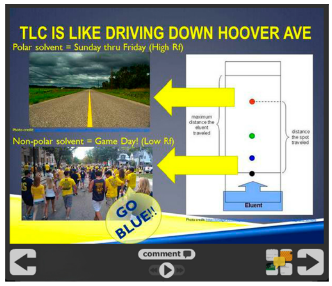



**Figure 2.** A screenshot of a student-generated metaphor, which compares TLC to driving down an Ann Arbor, MI, street on game day.

their interpretation. In this activity students practice spectral interpretation, use a standard index (SDBS or Reaxsys),[20,21] and use drawing software. Each student is assigned a different organic compound and prepares a slide with the labeled infrared spectrum and a drawing of the associated compound. The instructor monitors the responses to identify those bond stretches that were most challenging for students to interpret. Students are required to critique the posts of three of their peers looking for valid interpretation of data. The grading rubric requires correct assignment of all important bond stretches.

### Identification of an Unknown Compound

A classic problem-based organic chemistry experiment involves the identification of an unknown organic compound using various methods, including spectroscopic analysis and physical properties and standards.[22] In one laboratory exercise, students receive an unknown compound (1 of a possible 8) to analyze and identify. During the course of this exercise, students generate authentic data that they convert to electronic images using lab computers, smart phones, or other devices. Students arrange a slide containing electronic images of their data for upload (Figure 3) and subsequently explain the analysis of their

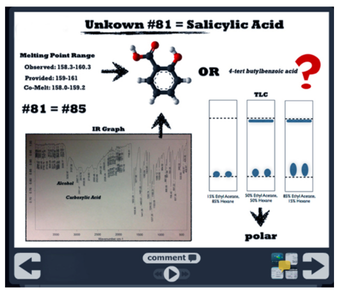



**Figure 3.** Screenshot of an example student post that includes an authentic infrared spectrum, which the student captured using their smartphone.

data and defend their identification of the unknown compound. The resulting student-generated explanations are informative for an instructor to identify specific incorrect or incomplete understandings within each characterization method and also in how students view the importance of each method as they use the information to identify and justify their final solution. Students are required to critique the posts of three peers who are not in their lab section and who do not already have three critiques.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## INSTRUCTOR TIPS

Student time spent on VoiceThread-based activities is minimal (30–60 min on average per week) though may vary with each assignment. Time spent also depends on each student's familiarity with technology. Because time investment is minimal, VoiceThread activities may be supplementary or used in place of lab reports or other homework.

Audio and video comments tend to be more spontaneous and thorough than text comments, and students benefit from practicing oral explanation of results. However, students will not readily use these features, as they are often uncomfortable recording their own voice. It is important to require that all comments, including both the original post and the peer critique comments, be made using audio or video tools. It is also beneficial to demonstrate the use of audio, video, and drawing tools for students when explaining the assignment during preparation of the instructor prompt on VoiceThread.

Peer critique is a key aspect of these activities. However, in general, students will not respond to the posts of others unless directed. Requirements for peer critique must be made explicit and specific for each assignment. An instructor may also demonstrate how to give an appropriate and helpful critique in the instructor prompt for students to model.

## SUMMARY

Student response to this system was largely positive (72%) as indicated by an open-ended question asking for students to share their general impression of the site. On an end-of-term attitudinal survey students were evenly divided on whether VoiceThread was easy to use (3.36/5.0 $N$ = 47 SD 0.94), whether it was helpful to see how others had perceived the same content (3.37/5.0, $N$ = 46, SD 0.93), and whether they learned from the assignments that others had posted (3.00/5.00, $N$ = 46, SD 0.88). Negative comments centered on the time spent on assignments and on the difficulty of using the VoiceThread site.

Explanation of data and lab results is a critical skill in research, and thus the activities described here are applicable to laboratory courses in any science discipline and are transportable to various other types of data and graphics. Assignments may also be refocused and tailored toward developing student use of expert terminology or used to investigate student strategies for responding to anomalous data. Other potential areas for further application may include analogous assignments modified for use in chemistry lecture or K–12 settings.

## ASSOCIATED CONTENT

### Supporting Information

Specific assignment descriptions, grading rubrics, and survey results are available via the Internet at http://pubs.acs.org.

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### Notes

The authors declare no competing financial interest.

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