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Using YouTube as a Platform for Teaching and Learning Solubility Rules

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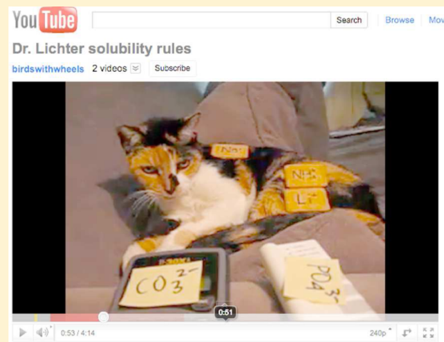
Supporting Information

ABSTRACT: Two challenges faced by university instructors in introductory chemistry courses are the need to keep the course material connected with technology that students are using as well as engaging students in a manner that keeps them interested in the subject. A case study is described where students in a general chemistry course were challenged to create and upload a video to the video-sharing Web site YouTube that could be used to learn solubility rules (which ions combine to form insoluble precipitates in dilute aqueous solutions). An assessment of the assignment was done by comparing results on a common exam question for courses with and without the assignment, as well as a follow up question on the final exam, survey questions, and comments. Results suggest that the solubility rules YouTube video assignment improved student learning of the rules and promoted interest in chemistry among a majority of the students involved in the activity.



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Students transitioning into university from high school will often attend an introductory chemistry course larger than any class they have experienced before. For example, in the 2009−2010 academic year, the average high school class size in Florida was 21.9 students.[1] In contrast, the average enrollment size for an introductory chemistry course at Florida International University during the same academic year was ∼200 students. Although there exists a range of research and opinions on the effect of class size toward learning outcomes and student interest,[2,3] there is no question that there are challenges to teaching a large chemistry course. Two of these challenges include the need to adapt to student learning styles by incorporating technologies and the importance of keeping students engaged and interested in the material.

With respect to technologies, nearly all of the current generation of students is dependent on cellular phones. Recent studies from Ball State University have shown that 99% of its college students have cell phones, 97% of the students used text messaging as their primary form of communication, and 53% of the students with cell phones use smart-phones, which have quick access to e-mail, Internet, and associated applications.[4−6] With the prevalence and rise in use of such devices, it will be advantageous to include the use of these devices for educational purposes to make learning more accessible. Successful cases of incorporating technology and social media in undergraduate and graduate chemistry classrooms have recently been reported. David Pursell of Georgia Gwinnett College demonstrated a high level of interest in the use of a flash card program on handheld devices as a supplementary tool for organic chemistry students learning nomenclature, structure, and mechanisms.[7] Pursell reported that students most appreciated the convenience of having the app on their cell phones. Adapting to student learning can also be extended to the incorporation of social media sites in assignments. Recently, Laura and Harry Pence reported using social tagging through the Web site Delicious[8] for bookmarking articles in undergraduate chemistry courses.[9] Students gave positive feedback with regards to enjoying contributing articles as supplementary for class time discussion. They also found the use of the social tagging to be valuable for assessing reliability and bias in the material they would find online. These examples highlight the advantage of bridging student learning with current technologies that students are using.

Considering the prevalence of cell phones and smart-phones among college students, it is no surprise that another issue faced in these large courses is the difficulty in maintaining students' attention during class. Traditionally, introductory chemistry is taught as a lecture course where an instructor or professor stands at the podium lecturing and assuming the role of the performer while the student serves as the audience. There exists a vast amount of research analyzing the effectiveness of traditional lectures on student learning compared to more constructivist and interactive approaches. In a comprehensive study of physics courses across high school and universities done in the 1990s, the traditional delivery of lectures was found to produce lower learning gains as compared to more engaged, interactive classrooms where student performance was encouraged.[10] In that study, the interactive

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classrooms included hands-on experiments, generally followed by student-led discussions. Such activities are usually difficult to facilitate in sizable classrooms without additional time and support. Often, lecture halls are not very conducive for such experiments or discussions, containing restrictive concert-hall type seating arrangements and difficult acoustics for unamplified discussions. These challenges of larger classes need to be met with innovative solutions that make chemistry more accessible both inside and outside of the classroom.

In the case study presented here, students were challenged to create and upload YouTube videos[11] that would be used to teach the rules of solubility (which ions form insoluble precipitates when combined in dilute solution). YouTube is a free online video repository that can be easily accessed on desktops, laptops, and smart phones. YouTube reports that it receives more than 2 billion visits per day and 35 h of video uploaded per minute, making it the most popular video Web site and a great platform for an assignment aimed at being accessible for students.[12] In general, a video assignment is valuable in that videos can be produced, edited, and watched all outside of class time, thereby maximizing the time spent in class for discussions, activities, and lectures. Using YouTube as the platform for this assignment allows students to watch the videos on their phones or laptops anywhere (with Internet capability) and at anytime of the day. Videos can also be saved to users accounts, watched as many times as the viewer pleases and reversed or forwarded through at the leisure of the person watching.

SOLUBILITY RULES VIDEO PROJECT DESIGN

In first-semester general chemistry, students learn how to classify different types of chemical reactions such as acid–base, redox, and precipitation reactions. To identify when precipitation reactions occur, students are asked to understand the solubility rules. For example, at basic or neutral aqueous conditions, carbonate forms an insoluble precipitate when mixed with any cation (other than the group I or ammonium). The accumulation of solid white calcium carbonate deposits along the walls and floors of swimming pools (a process called scaling) is a practical example of this. Such information about which ions combine to form precipitates is presented in chemistry textbooks in tabulated form, often explaining which pairs are always soluble, slightly soluble, and never soluble (Table 1). Along with the textbook and in-class lecture and discussion, students verify these rules in a requisite laboratory component, performing an experiment where they observe mixing cations and anions in aqueous solutions.

In an effort to make learning these rules more engaging, students were challenged to produce a YouTube video that could be used to help themselves and others learn them. The guidelines for the video project were as follows: (a) the solubility rules had to be completely covered (as seen in Table 1) and must be audible, visible, and easy to understand, and (b) the video must be posted to YouTube so that the rest of the class (and world) could view the project. The group size was limited to 5–6 people and stipulations were given that upon submission of their video link, all group members must provide proof of how they were involved in the video. The class was given the assignment five weeks in advance to the second exam. The project was not mandatory but the incentive for making the video was a potential 10 points extra credit toward their second exam (out of 100 points), which amounted to a potential 1.7% increase in their final grade in the course (out of 100%). The rubric for grading the videos was based on a 10-point scale divided into three sections: 4 points for completion and correctness of the rules, 3 points for creativity, and 3 points for production (see the Supporting Information). Students were required to submit the video one week prior to the exam, at which point links for the videos were disseminated to the entire class. Reminders were given during class and via e-mail that videos had been posted and that they should be used as supplementary study tools.

Table 1. A Tabulated Representation of the Solubility Rules That Are Commonplace in General Chemistry Textbooks

Compounds Containing the Following Ions Are Generally Soluble	Exceptions
Group I and NH_4^+	none
NO_3^- and $C_2H_3O_2^-$	none
Cl^-, Br^-, and I^-	when paired with Ag^+, Hg_2^{2+}, or Pb^{2+} (insoluble)
SO_4^{2-}	when paired with Sr^{2+}, Ba^{2+}, Pb^{2+}, Ag^+, or Ca^{2+} (insoluble)
Compounds Containing the Following Ions Are Generally Insoluble	**Exceptions**
S^{2-}	when paired with group I, NH_4^+, Ca^{2+}, Sr^{2+}, or Ba^{2+} (soluble)
OH^-	when paired with group I and NH_4^+ (soluble)
	or when paired with Ca^{2+}, Sr^{2+}, or Ba^{2+} (slightly soluble)
CO_3^{2-} and PO_4^{3-}	when paired with group I or NH_4^+

YOUTUBE VIDEOS AND ASSESSMENT

Seventeen groups (N = 48 students; 27% of the class) submitted solubility rules videos to YouTube. The assortment of videos included original songs, song parodies, television show parodies, movie parodies, short stories (with creative mnemonic devices in each story) and one student designed a video called "stuff on pets" where the interaction of her pets with items representing ions was used to show a precipitation reaction (when the pets showed interest) and no precipitation reaction (when the pets paid no attention) (Figure 1).[13] The videos varied in length (2–10 min long), creativity, and production. The videos were graded based on the rubric and the average score for the videos was 7.5 out of 10 points. During the one week period from when videos were posted and the second exam was given, some of the videos had reached ~150–200 views, suggesting the possibility that either a good

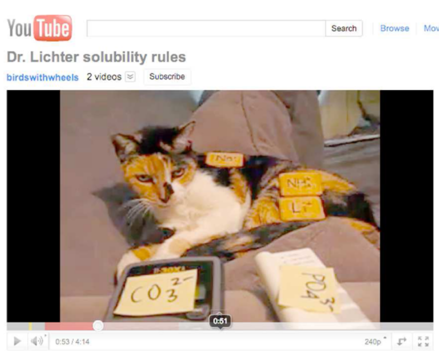

Figure 1. In "Stuff on Pets", a cat is shown eliciting no reaction when group 1 and ammonium cations are placed next to carbonate and phosphate, consistent with the solubility rules (which state that these do not form insoluble precipitates).

number of students were watching the videos, a small group of students were watching the videos repeatedly, or some combination of the two. A more accurate assessment of the frequency of students watching videos was done via questionnaire, discussed below.

To assess the effectiveness of the YouTube videos on student learning outcomes, a common exam question about solubility was asked on the second exam. The question was moderate in difficulty level, asking to identify which of three ionic compounds shown would be soluble in dilute aqueous solution (Figure 2). The common exam question was given to students

Which of the following compounds is/are soluble in aqueous solution?

i. $Zn(NO_3)_2$
ii. Na_2CO_3
iii. CoS

A. i and iii
B. ii only
C. i and ii
D. i only
E. i, ii, and iii

Figure 2. Common exam question used for assessment (the answer is in bold).

in the course with the assignment and to students in a parallel introductory chemistry course without the assignment (taught at the same university during the same semester by a different professor). Both courses used the same textbook and the instructors of both classes agreed to teach solubility rules similarly during class time (~15 min of class lecture, 4−5 PowerPoint slides, and 1−2 quiz questions).

Students who were in the class where the YouTube project was assigned did significantly better on that question (66.9% correct) than those students in the class where there was no video assignment (48.3% correct) [χ^2 (1,N = 384) = 13.47, p < 0.001] (Table 2). There was no significant difference between

Table 2. Assessment of Solubility Rules Question on Second Exam

Students	Students Who Answered Correctly (%)	Total Number of Students
... in class that had video assignment	66.9	181
... and made videos	81.3	48
... and did not make videos	61.7	133
... in class that did not have video assignment	48.3	203

the overall exam averages by class (with assignment, 59 ± 26%; without assignment, 56 ± 21%), [t(382) = 1.42, p < 0.158]. In the class with the YouTube assignment, the percentage of students who answered the specific question correctly was significantly greater for those who made videos (81.3%) than those who did not make videos (61.7%) [χ^2 (1,N = 181) = 6.11, p < 0.013]. These data suggest a relationship between the level of involvement in the assignment and the results on the exam question, with those who made videos scoring best, and those who neither performed nor watched videos scoring lowest. The concern that the classes being compared were taught by different instructors and as a result the data might be affected by that more so than the YouTube assignment was addressed by comparing the solubility rules question on this exam with that of previous semesters (when no video project was assigned) for the instructor where the assignment was given. It was found that the historical average on a similar question was ~52%, 15% lower than the results discussed above, suggesting the instructor's role was insignificant in the results of this study.

Incentivizing students with extra credit can lead to a bias where only top, motivated students take part in the assignment. An analysis of the video makers' final grades in the course confirmed that on average they received a higher letter grade than the rest of the class. Making the assignment mandatory might remove this element of self-selection, yet it brings with it a risk of poorly produced or mistake-ridden videos. Interestingly though, those in the class with the assignment who *did not* make videos did significantly better (on the solubility rules question) than the class without the assignment [χ^2(1,N = 336) = 5.78, p < 0.016]. This statistics suggests that the real value in this assignment is the peer-to-peer instruction that occurred. By harnessing the creativity and workmanship of the top students, the remainder of the class learned the material more effectively than just learning from the instructor, textbook, and class material.

Another concern when putting this case study together was whether the assignment would have short-term or long-term impact on students understanding of solubility rules. Results from a solubility question of similar difficulty on the final exam were analyzed (Table 3). The students who made videos still

Table 3. Assessment of Solubility Rules Question on Final Exam

Students	Students Who Answered Correctly (%)	Number of Students
... in class that had video assignment	49.1	164
... and made videos	63.0	46
... and did not make videos	43.2	118

performed significantly better than those who did not [χ^2(1,N = 164) = 5.21, p < 0.023], suggesting that the video project helped with retention of the rules.

Following the completion of the second exam, students were surveyed in class about the video assignment. The first question asked was how much students had spent watching the videos. Forty-seven percent of the students surveyed (N = 129) watched the videos from 10 min to 1 h, 33% watched from 1 s to 10 min, 9% of the students had even watched the videos from 1 to 4 h. Most surprising was the small percentage of students surveyed who did not watch the videos at all (11%). Even though only 27% of the class made videos, 89% of the class watched them. Although this could be attributed to reminders given in class, it is more likely a result of ease in accessibility and because they were entertaining. Considering the one-week time span between the day the links were posted to the class Web site and their second exam, it is possible that a longer viewing period might have increased the percentage of students who watched the videos and the time spent watching them.

When asked to what extent the videos were used as a studying tool, the entire class was neutral about preferring the videos over lecture notes or their textbooks, but they did agree that watching the videos made studying the topic easier and made the course more enjoyable (Table 4). The students who made videos were surveyed separately from the entire class and strongly agreed that the videos helped them in studying for the exam. When asked to give some individual comments regarding the video assignment, students said the following:

Table 4. Attitudinal Assessment of Solubility Rules Video Assignment

Statement	Average Score[a]	Number of Students Surveyed
I used the videos to study solubility, more than lecture notes.	2.9	130
I used the videos to study solubility, more than I used the textbook.	2.6	131
The videos made studying solubility rules easier.	3.6	131
The videos made general chemistry class more enjoyable.	3.9	131
Making the video, helped me study for the exam.	4.5	47
Making the video, helped increase my interest in general chemistry.	3.6	43

[a]Statement responses done using the following scale: 5-strongly agree; 4-agree; 3-neutral; 2-disagree; 1- strongly disagree.

> "The solubility rules video was a great tool to learn material that could otherwise have been a headache to memorize."
> "Using things relevant to me, such as music and humor to make the video, enhanced my learning process."
> "It was a fun way to learn the rules."
> "It took my group one day to film the video and maybe about 3 or 4 to edit it. It didn't interfere with my studying for the second exam."
> "The thing I liked most is that I actually studied without even knowing it."
> "I would definitely keep this assignment going if I were teaching because it allows students to come out of their comfort zone and do something fun for chemistry."

■ CONCLUSION

The solubility rules YouTube assignment was an effective example where students can "learn by performing" as opposed to "learn by listening". The assignment led to the production of 17 videos of varied styles, creativity, and production value. Although only 27% of the class made videos, almost the entire class watched them for some manner of time. Considering the prevalence of cell phones with video recording capability, it seems unlikely that the somewhat low turnout in videos produced could be attributed to lack of video equipment. The guidelines specifically stated that if the videos were not well produced they would not be receiving credit, so perhaps students felt less inclined to produce something without guarantee of extra credit.

The videos produced served as a studying tool for students who performed the videos, their classmates, and can continue to serve as a study tool for anyone who watches them now that the videos are available on YouTube. The assignment worked well as a supplement, having been completely accomplished outside of the classroom. The amount of time students reported spending on the video assignment ranged from 1 to 5 days. Although that might seem like a lot of time focusing on a minor topic, the assignment helped to promote interest in the class, led to students formulating study groups, and it generated a lot of positive feedback.

The use of videos, skits, and songs to study chemistry is not a novel idea, having been utilized and reported in other universities and chemistry classrooms ([14−17]). The case study presented here sought to measure student performance and student interest in chemistry as a result of this type of assignment. The result was improvement in performance and heightened interest in the subject. The students who made videos did significantly better than the rest of their classmates in remembering the solubility rules. Remarkably, students who did not make videos but watched them did better than students who did not produce or watch videos. The suggestion here is that the dissemination of student performances to the entire class can impact comprehension and learning for classmates, even if they still maintain an audience role. Comments made about the assignment generally focused on how easy and fun the assignment was and how it made chemistry more entertaining.

This type of assignment, where students are encouraged to perform the material they are learning, should be considered as a viable supplement for introductory chemistry courses, especially for material that is generally tough for students to learn. The rules of solubility were a good topic because the material is presented in the textbook in tabulated form, which students generally memorize. This process can be challenging for students who need hands-on activities to learn such concepts. Other introductory chemistry topics that necessitate the same type of studying techniques could be taught using a PEL assignment. Topics that might also be considered include nomenclature (elements and compounds), electron configurations, and identifying weak and strong acids. Such topics usually require memorization, which can oftentimes be seen as tedious and boring. The implementation of a fun assignment such as this one, helped to promote some student interest rather than detract from it. Yet, the potential exists to incorporate video projects for conceptual understanding and also practical applications of topics in general chemistry. Done correctly, this type of project can help increase student understanding of any material while bringing an element of enjoyment to the process.

■ ASSOCIATED CONTENT

Supporting Information

Grading rubric for the video. This material is 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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