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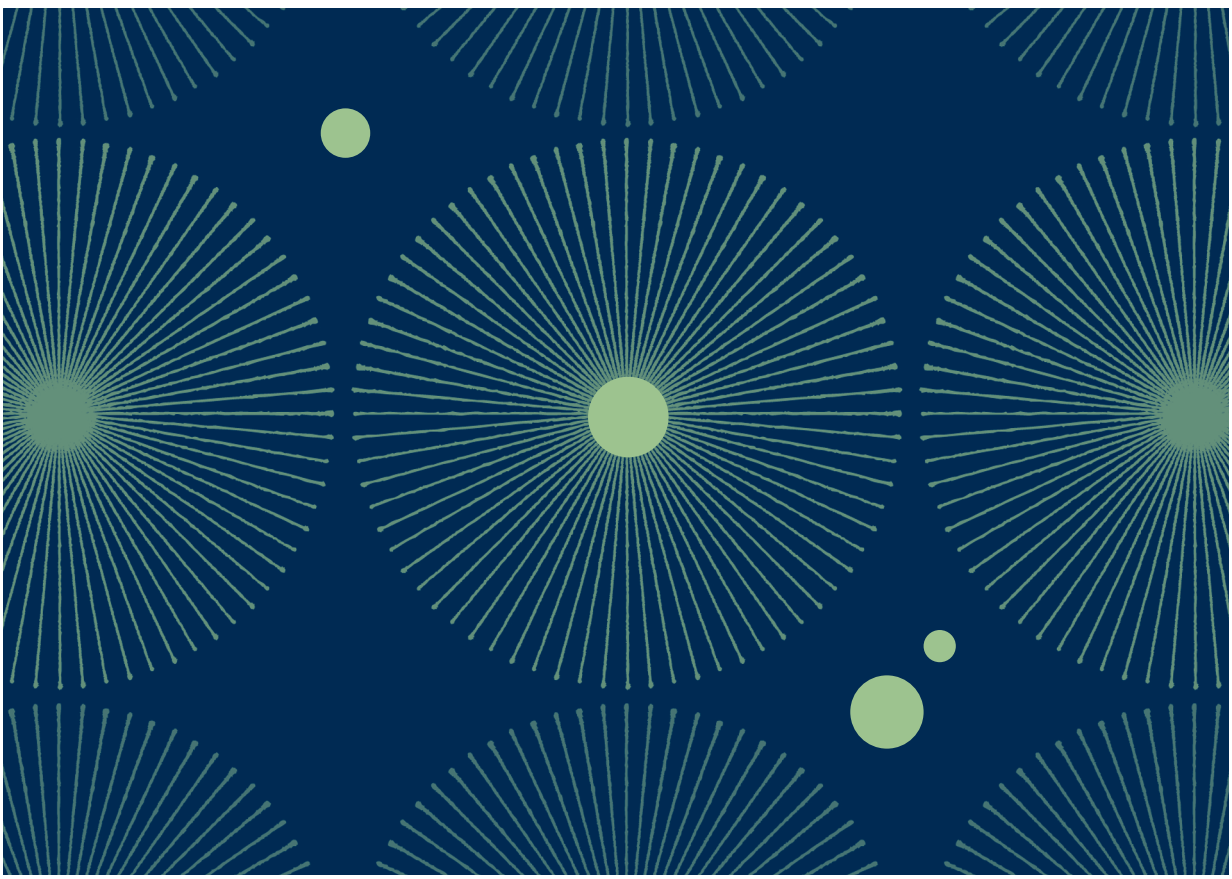
Published in:
Proceedings of the 2nd Association for Visual Pedagogy Conference

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

UNDERVISNING OG LÆRING

Proceedings of the 2nd Association for Visual Pedagogy Conference



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Proceedings of the 2nd Association for Visual Pedagogy Conference

Kathrin Otrel-Cass (red.)
Proceedings of the 2nd Association for Visual Pedagogy Conference

1. udgave, 1. oplag, 2017

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Omslagsdesign: Studio Sabine Brandt
Grafisk produktion: Dafolo A/S, Frederikshavn

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Svanemærket trykkeri 50410816

Serie: Undervisning og læring
ISSN 2246-3259

ISBN 978-87-7160-659-1

Strengthening problem solving skills in organic chemistry: videos and online activities for active learning in engineering education

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Introduction

Acquisition of knowledge and the ability to solve problems in organic chemistry is demanding and requires that students actively engage in the application of new knowledge and continue to practice it. This is so since the processes organic chemistry is dealing with are typically at a molecular level and not directly observable (Graulich, 2015; Kozma & Russell, 1997). This constitutes a challenge for University teachers on how to ensure that students acquire the competencies to make deep level connections and are able to interpret chemical representations, suggest selected mechanisms, or make analytical evaluations based on the structure–reactivity relationship (Graulich, 2015).

Graulich (2015) explains that in fact one of the challenges in organic chemistry that directly impact on student performance have to do with representational competence, spatial ability, and scientific reasoning strategies. The aim and challenge was therefore to review ways to support students "learning about and retaining designed tools and representational systems that mediate between something that they cannot see and something that they can" (Kozma, Chin, Russell, & Marx, 2000, p. 106). Benedict and Pence (2012) report supplementing in class chemistry activities with online material including videos that can be accessed through smartphones. Some of those videos were given as homework where students had to prepare videos where they had to perform a procedure or use an instrument. Those videos were then shared as a resource and received very positively from students. In our case, we wanted to explore if a similar effect could be achieved by asking students to produce videos and interact online to enhance them solving a range of chemistry assignments.

Context

The case that is presented here is set in the context of a problem based learning (PBL) University where part of the traditional teaching approach includes

that students work in groups and spend time problems solving. Typically, the learning activities are focused on face to face classes, using digital resources as supplementary material. The specific case is a second-year undergraduate students enrolled in an organic chemistry course which is part of an engineering education. In previous years failing rates in this course were very high (between 40 and 70%). It seemed that students were not practicing the concepts and reactions enough by themselves outside of class time. As a consequence of that, it seemed that students could not remember things they had learned in previous classes. In this study four types of interventions were implemented in a semester course. The fours activities included that students had to produce their own videos, have access to externally produced videos, participate in group discussions and whole class discussion in an online forum. This was a novel approach since this University programme is typically based on face-to-face teaching, face-to-face group work, where online material is typically only used as supplementary resource that students can choose to utilize.

Student assignments – Videoed chemistry assignments

The main intervention was to ask second year undergraduate students to video record themselves solving chemistry assignments. The students were provided with instructions on how to produce videos using their cellphones. A link to a video produced by VILA, the Video Research Lab at Aalborg University was posted in the Learning Management System Moodle. The video explained on how to record, transfer and download videos. The production of the videos did not require an expensive program or equipment, and could be recorded using an ordinary smartphone. Once produced the videos were uploaded to Moodle where both teacher and students had access. The student assignments had to be solved individually within a week. The task was to solve reactions in writing and verbally explain the mechanism and record this on video. Each student received two sets of individual assignments during the whole course. The first task was to solve rather simple reactions. The aim was that this could help students and the teacher to test knowledge of rather simple chemical reactions. The second task was an assemblage of multiple step reactions, where either the start and stop compound was given or the start compound in combination with the reactants. The second task constituted a far more demanding task to test the student's ability to solve a more complex problem by applying their knowledge in a broader context. The video recorded assignments were assessed by the teacher and individual feedback was given via email. Overall feedback on

the handed in assignments was given in class by solving the problems together with the students.

Student assignments – Online group discussions

The second out of class activity was a group activity aimed at strengthening the learning processes within each group. Student groups were tasked to find relevant reactions in the literature and exchange it with a second group. The second group needed to solve the reaction and explain the mechanisms. The first group was peer reviewing the solved task. In the end, the teacher assessed the whole process and gave feedback to each of the groups. The teacher was responsible for assigning the roles of the groups within the whole task. The whole task had to be completed within one week. A rotating system ensured that all groups were equally assigned all roles.

Student resources – Externally produced videos

To further improve the understanding of such difficult concepts, short videos explaining these topics were provided by the teacher as additional material. These videos were typically 3-10 minutes in duration describing one topic/concept only. Platforms such as YouTube provide a large number of short video clips which can be accessed free of charge. These videos used frequently visual aspects and were selected on the basis to support and deepen the understanding of a taught topic/concept.

Student support – Online forum discussions

The final out of class activity, was an online discussion using Moodle as the platform. The process involved that the teacher started a discussion on a selected topic from the previous classes and the students were asked to contribute to the discussion. The selected topics were typically covering fundamental concepts or more complex topics which required a deeper understanding of the subject. The discussion platform should provide students with the possibility to exchange knowledge and get better explanations on difficult topics. Due to time constraints and an evaluation on participation the online discussion activity was not carried out throughout the entire course. In parts, this was because it turned out to be rather difficult for the students to select the topics themselves. All of the above mentioned out of class activities were made part of the assessment and contributed to the final grade of the course. Students had regular updates on how they had performed.

Findings

At the end of the semester all students had to complete a written exam. Most students had already collected a good number of points throughout the semester so they may have felt less pressure to perform well in the written exam. However, the student motivation was high and almost all students attended and passed the written exam. The failure rate of the course was reduced from around 40-70 % down to 13 %. The written test was set at the same level as in the previous five years. After the course had been completed the teacher received very positive feedback from the students. They felt engaged and liked the activities. They could also feel the progress in their own learning process. It was not conclusive if the online discussions had been of much value but the videos both students produced and resource videos were much appreciated. This approach of including a number of assessment tasks throughout the course that include also video allowed the teacher to identify very quickly problematic issues that needed to be discussed in class. The videos also provided a resource to the students to be used in the preparation for their final exam.

Preparation of all the out of class activities were quite time consuming for the teacher. To set up all activities as well as to identify useful video material online and find the appropriate chemical reactions for the individual assignments was rather work intensive. However, having the organization and resources in Moodle once established, the time required to run the course again will be reduced since it takes only limited time to revise and update the course. The number of students attending the course was rather low (around 20 students). To implement all out of class activities in a course with a large number of students can be a big challenge. In this case, maybe not all out of class activities should be considered or some of the activities need to be adjusted in such a way that the students are more involved in the peer reviewing process.

Conclusion

Much of the research on learning chemistry focuses on student deficiencies. While it is important to have a good idea about what students struggle with we echo Graulich's (2015) call to share positive stories. We were able to show examples on how students succeeded building their own resources, through relatively simple strategies. Especially the production and viewing of videos turned out to be a successful strategy that may have helped students to overcome the obstacles in practicing and 'talking' organic chemistry. Future research may look into conducting long term studies to investigate the use of video to exa-

mine how this supports identity formation, positive reinforcement and competency development.

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