

## EVALUATION OF THE USE OF FLIPPED CLASSROOM BASED TUTORIALS IN “MATHEMATICS FOR CHEMISTS” COURSE FROM STUDENTS’ PERSPECTIVE

Ahmad Aljanazrah  
Birzeit University, Palestine

Franz Josef Schmitt  
Technische Universität Berlin, Germany

Thomas Friedrich  
Technische Universität Berlin, Germany

**ABSTRACT:** Use of “Flipped Classroom” is gaining more and more interest in chemistry education. Within a project “educationZen” to enhance the quality of chemistry education using digital technologies at the Technische Universität Berlin, “Mathematics for Chemists I and II” courses have been implemented based on targeted flipped teaching approach. Students have been provided with online instructional videos about some of the topics addressed in the lecture and the face-to-face (tutorials) real time was used for other student-centered activities like cooperative problem solving and peer marking. The purpose of this study was to evaluate this experiment of applying flipped-classroom based tutorials to those courses from students’ perspectives and to explore those views within the frame of their digital habits and attitudes toward the use of educational technologies in teaching and learning of chemistry. In order to achieve the purpose of the study a combined quantitative–qualitative approach has been applied. The first part focuses on measuring students’ digital habits and their attitudes toward the use of educational technologies. It was based on quantitative analysis of data that was gathered through online and face-to-face questionnaires. Qualitative evaluation was used to explore and examine the students’ perceptions through focus group interviews. Findings have shown that 95% of the students are using internet more than one hour a day and most of the students liked to use online videos to support their studies. Students’ attitudes were positive toward the use of digital technologies to enhance their chemistry learning but not to substitute the role of the lecturer. Most of students still value face-to-face interaction and do not see online learning environment as a total substitution to the traditional lecture even in the future. Study findings strongly recommend applying the online instructional videos in chemistry education and to extend this model to other courses and topics.

**Keywords:** flipped classroom, chemistry education, online videos, blended learning, technology in university teaching.

### INTRODUCTION

There is a growing evidence in the literature, indicating that the use of Information and Communication Technologies (ICTs) has the potential to enhance the quality of science teaching and learning in both school- and higher education levels (Slavin, Lake, Hanley & Thurston, 2014 and Lee, S. et al., 2011). According to the International Association for the Evaluation of Educational Achievement (IEA) Second Information Technology in Education Study (Law, N., & Chow, A., 2008), ICT-use in teaching and learning brings a stronger 21st-century orientation to pedagogy in both mathematics and science classrooms. In addition, younger generations of students are becoming more and more dependent on the different forms of electronic devices such as smartphones, tablets and computers as well as online resources (Cassidy, et al., 2014). One of those most common technologies is the use of online instructional videos. Instructional videos, sometimes called tutorial videos or lecture videos, are usually made up of instructors’ audio narrative added to Microsoft offices screens that display topic content (Brecht, 2012). Other technologies allow producing tutoring videos that are based on voice and handwriting which are similar to the traditional face-to-face tutoring using writing and explanation (He, Swenson and Lents, 2012). It has been found that instructional videos can increase learner engagement, control of learning and independence. Chemistry students can access and watch those videos whenever they want and wherever they are if they have internet access; and more important they can listen to them repeatedly as needed depending on their own pace of learning (Zahng et. al., 2006; Simpson, 2006). Use of video and multimedia can capture students’ interest and demonstrate events, internet can provide rich environment of resources and online communication and support, and virtual experimentation can enhance what is so-called “minds-on” activities, which can enhance higher order cognitive skills (Wellington, J. & Ireson, G, 2012).

In a traditional lecture set, an instructor goes usually with all students with the same pace, trying not to be too fast for slow learners and not too boring for fast ones assuming that they all can follow him or her on this average mode. The cognitive school of learning recognizes the importance of taking into account individual differences in designing learning environments (Ally, 2004). As a result, the flexibility of repeating in-class activities in a form of instructional video offers an overwhelming advantage by enabling the students' control of passing information transfer to fit their pace of learning rather than in a traditional lecture setting. The constructivist school of learning sees learners as being active rather than passive and one of its' implications to online learning that learning should be interactive to promote meaningful and deep learning (Ally, 2004, p. 20). Online instructional videos provide learner-content interactivity by allowing proactive and random students' access to video content.

Integrating educational technologies in learning settings may initiate new pedagogy. Blended or hybrid learning in which face-to-face sessions (traditional lectures) are mixed or replaced by online sessions is an example of this new form of pedagogy and/ or training (Aljanazrah, 2005) Other forms include what is called "flipped or inverted classrooms". Although there is no one specific form of flipped classrooms, the core idea of this form is that instruction which used to take place in class is accessed in advance at home (or another place where internet is available) through teacher pre-created/ recorded online videos; while, in-class time is used for doing other student-centered activities such as solving problems, deepen concepts or working out cooperative assignments (Tucker, 2012). Following this approach, watching online videos in advance can enhance students' preparation and allow for investment in the real time lecture (face-to-face instruction) for scaffolded-practice and applied learning (Christiansen, 2014). According to Schultz et. al. (2014) flipped-class chemistry students' performed better and even had a favorable perception about this approach, that is learn at home and practice in class.

It has been reported, more than 45 years ago, that students view chemistry as a subject area that can only be understood by talented students (Scheible, 1969). This view about the complexity of chemistry continued until current days (Chen, 2013). This can be explained not only because of many concepts studied in chemistry are very abstract but also many students usually fail to connect the macroscopic phenomena with the microscopic world of atoms and molecules (Gellespie, 1997) and teaching chemistry occurs predominantly on the most abstract level (Gabel, 1999). In order to reduce this level of abstractness and complexity, there has been a continuous trend to use Information and Communication Technologies (ICTs) in teaching and learning chemistry. According to UNESCO (2007) ICT "refers to forms of technology that are used to transmit, process, store, create, display, share or exchange information by electronic means". Promising examples of those electronic tools are the different forms of multimedia and molecular visualization. According to the cognitive theory, meaningful and deeper learning is more likely to occur when students are able mentally to connect both verbal (words) and pictorial (pictures, models, animations...) representations simultaneously (Robinson, 2004).

### **Research Problem and the educationZen Concept**

Mathematics courses offered for chemistry (science) students at the Technical University of Berlin (TU-Berlin) usually are accompanied with tutorials (lecture and discussion model). Those tutorial sessions supplement the regular lecture and are conducted by teaching assistants who summarize and clarify important lecture materials and discuss and answer required homework problems. As in lectures, tutorials tend to emphasize teaching rather than learning using the so called "Chalk Talks" format (Hudson & Luska, 2013) but with smaller numbers of students and more space for question-answer discussions.

With the aim of enhancing the quality of chemistry students' learning by moving to a more student-centered learning environment, a new form of tutorials within the frame the educationZen project has been created. The new structure is based on a partial flipped teaching approach in which students will be provided with online instructional videos about some of the topics addressed in the lecture and thus, has the opportunity to use all the tutorial (face to face) time for other student-centered activities like cooperative problem solving and peer marking, as seen in Figure 1.

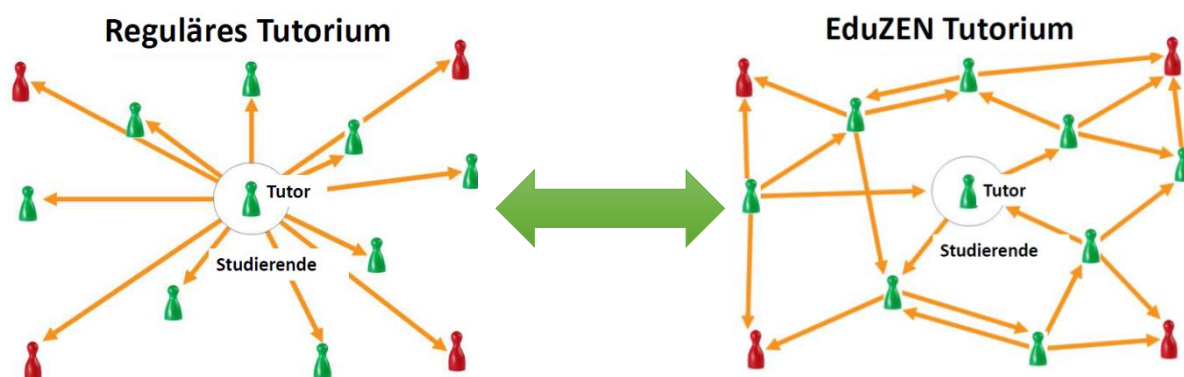


Figure 1: Shifting From Teacher-Centered Toward More Student-Interactive Approach.

The aim of this research is to evaluate the implementation of a newly developed targeted flipped form of tutorials from students' perspectives. In this form, students will have the opportunity to access online learning materials in form of educational videos before coming to the face-to-face tutorials. One of the ideas behind this format, as indicated above in the literature, is to allow students to have more time for applications and cooperative problem-solving activities when they meet in face-to-face sessions (tutorials).

## METHODS

In order to achieve the purpose of the study the following research questions have been formulated:

1. What are the digital habits of students attending "Mathematics for Chemists" course?
2. What are students' attitudes toward the use of educational technologies in teaching and learning chemistry?
3. How do students experienced the new form of flipped classroom based tutorials?
4. How do students evaluate the provided online instructional videos?

Quantitative descriptive methodology was used to answer the first two research questions in order to identify students' digital habits and their attitudes toward the educational uses of digital technologies. While qualitative research methodology was followed to answer the third and fourth research questions which represent the core aim of this research. More specifically, qualitative illuminative evaluation (Savin-Baden and Major, 2013)

### Research Tools

The quantitative part of the research was addressed through a questionnaire that has been developed to answer the first and second questions of the research. This questionnaire consists of three main components: personal data, students' digital habits and students' attitude toward the use of Information and Communication Technologies in education. The evaluation of the use of flipped-class tutorials including online videos and other provided online learning resources and communication, took place through focus group interviews, accompanied with one-page checklists and written questions. The selection of focus group interviews as an evaluative method is because they can help us to gather information about students' perceptions related to the new structured tutorial and online resources in a more deep and flexible environment. It was important to know what the students think about those issues and to try to understand why do they think so (Savin-Baden and Major, 2013, p. 375). While the checklists/written questions asked about information that students may tend not to answer it in public but very relevant to the evaluation.

Content validity was used with the questionnaire that was developed in the light of previous literature and the focus group interviews was given to different instructors of the course "Mathematics for Chemists" and was modified according to their feedback. In addition, the focus group interview questions were modified again after piloting an interview to a group of students.

The questionnaire was sent to all students of the course, a total number of 170 students, and the number of received questionnaires was 73, the response rate was 0.43. Descriptive statistical analysis was applied to the data collected by the questionnaire. Five focus group interviews took place including the first one as a pilot. The interviews were administered by the main researcher and assistant, recorded and then transcribed as text. During the interviews

voting was used to seek for agreements and common ideas. Thematic analysis was used to analyze qualitative data through the interviews.

Online videos were developed by the course tutors, uploaded and announced to the students through the course portal (ISIS: a learning management system adapted from MOODLE especially for the Technical University of Berlin) one week before session. The video used a simple technology in which the instructor voice and writing were synchronized.

## RESULTS AND FINDINGS

Exploring the digital habits of students showed heavy rely on technology, 95% of the students are at least one hour and more than half of them are at least 3 hours online per day, as well as high rate of access 98.3%, figure 2 and 3. Such results are very much supported in the literature; according to Cassidy et al. (2014) 99% of the students had access to Internet at home. The results also indicated that most of the students watch online videos, which come in line with what was in the same research of Cassidy, et al. above in which 98.8% of the students ranked YouTube as the most popular technology.

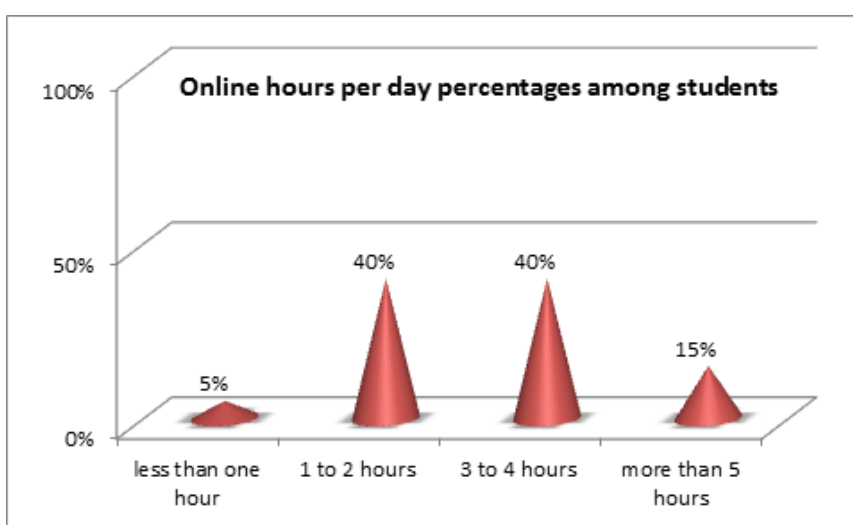


Figure 2: Students' Usage of Internet per Day

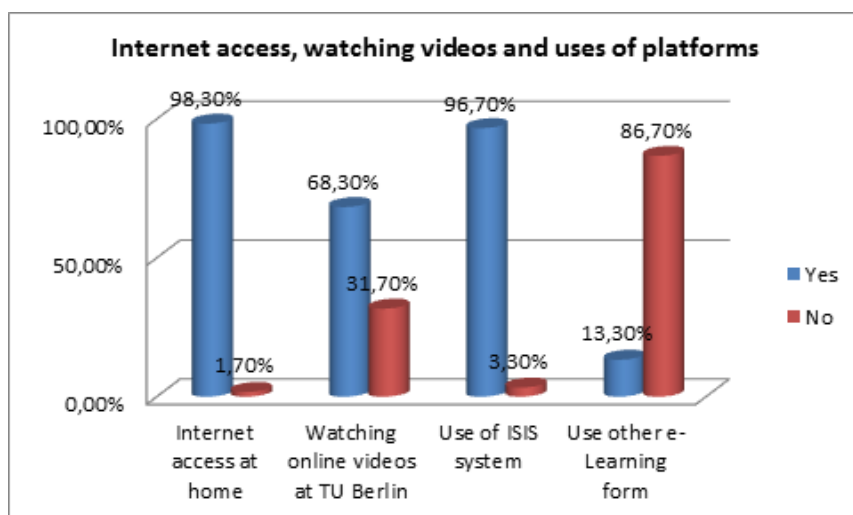


Figure 2: Students' Access and Uses of Internet

Students expressed positive views regarding technologies. If we add the agree and totally agree percentages, best results go to the use of online videos as support for students' studies, the first and last statements in figure 3, explains this results since many students think that those videos and illustrations have helped them to better understand chemistry topics. The best totally agrees result shows that students, despite their heavy use of digital

technologies, still tend to prefer face-to-face interactions with their colleagues when compared to online interaction.

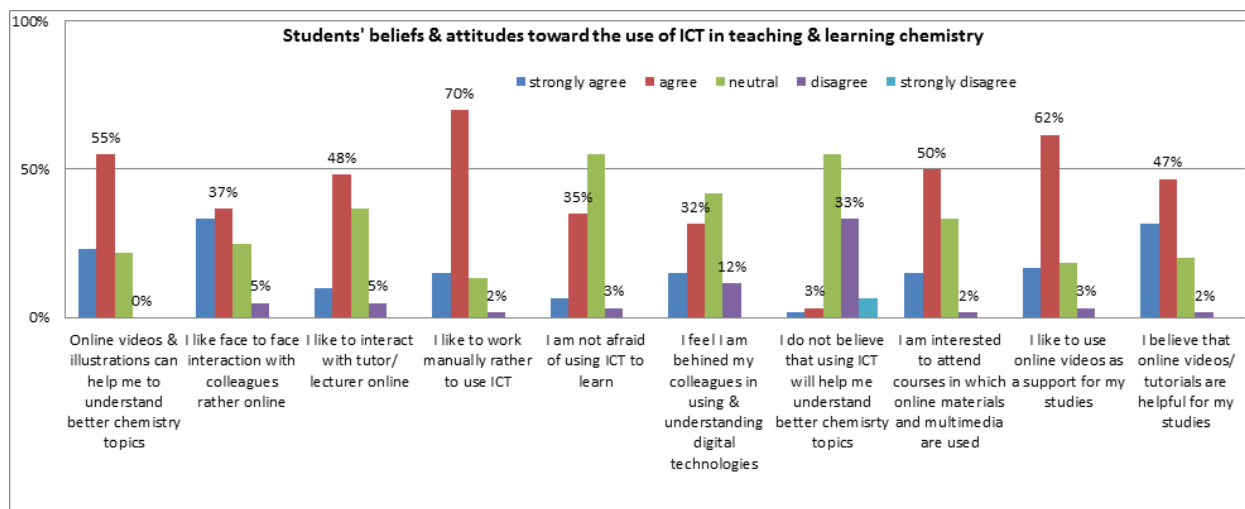


Figure 3: Students' Attitudes toward Educational Uses of Technologies

The results of the focus group interviews confirmed the positive role of the online videos “...*gut gemacht, man kann gut folgen..., praktisch*”, even more students mentioned examples how those videos were of benefit when they missed their tutorials. One of the examples, students who were sick found the videos helpful as sources for learning “... *weil ich den einen Tag Krank gewesen bin, habe ich die Videos angeguckt, es war hilfreich...*” The content of the videos and how it was delivered affected evaluations of those videos. Students found those videos more helpful when their content was easy. When the level of difficulty/complexity of the videos' content increased, students lost their interest to watch them”.

Students indicated that the use of videos made the tutorials more effective and quicker. This was very beneficial, especially that the students are under big study load from other courses “*Man macht echt richtig alles schneller*”, “*weil es erstens schneller geht und man effektiver in einem kuerzeren Zeitraum die Sachen verstehen kann*”. Many students used the online videos for preparation for the tests and found them of great value in this regard “*Ich denk mal die Videos sind auch richtig praktisch vor der Klausur, wennn man da eine Menge Stoff hatte, und man anfaengt und dann die ersten Aufgaben nicht mehr Weiss, dass man da vielleicht nochmal sich die anschauen kann*”

Many students rated highly the new format of (inverted targeted) tutorial. Students studied at home through the online videos and when they come to the face-to-face tutorial they worked in small groups on solving problems and getting deeper understanding of the materials “...*das ist das beste Tutorial dass ich gehabt habe, weil wir zu Hause die Videos angeschaut und dann arbeiten wir in kleinere Gruppen zusammen...*”. Some students mentioned that they prefer the traditional way of the tutorials and felt that inverted form of tutorials sometimes represented a repetition for the materials and felt more confident when the tutor explained in face-to-face the mathematical solutions of the problems. They mentioned the huge traffic of emails and that many of them should not be published to all students on the portal, especially the answers to students' questions that should not be also important for the others.

In general, the students tend to advise their colleagues to attend courses of similar targeted-inverted format because of the high online support they receive by tutors more than in other similar courses.

### CONCLUSION

Inverted classroom represents a promising pedagogy in Higher Education. It represents a response to the changing characteristics of the new generations of the students who rely more and more on digital technologies. Results of this research confirmed the benefits of using online videos that helped students not only to prepare for their tutorials but also for their exams; they overcome the limitations of time and place and provided more time for active learning and applications during the face-to-face tutorials. At the same time, some students expressed their uncertainties regarding the new form of pedagogy but nearly all of them like to have technology supporting lectures and tutorials but substituting them. Further exploration of this inverted approach is needed to other topics and other contexts as well as evaluation of this model from tutors/ teachers' perspectives.

## RECOMMENDATIONS

The positive evaluation of the inverted-model of the tutorials suggests that it has the potential to enhance the quality of chemistry and math education at the university level. Those results recommend using more online learning resources like videos combined active learning applications. Results also recommend the blended model and not the total substitution of face-to-face interaction by online videos. In addition, extension of model implementation and evaluation to other courses, topics and contexts in higher education is recommended. This is important to uncover new advantages and/ or limitations of the targeted-inverted classroom model.

## REFERENCES

- Aljanazrah, A.M. (2006). *Development, implementation and evaluation of a new chemistry teacher in-service training model based on Blended Learning*, Shaker Verlag
- Ally, M. (2004). *Foundations of educational theory for online learning*. In: Anderson T., Elloumi, F. (Eds.) *Theory and practice of online learning*, Athabasca University, pp. 1-31
- Baker, J. W. (2000). The “Classroom Flip”: Using web course management tools to become the guide by the side. In J. A. Chambers (Ed.), *Selected papers from the 11th International Conference on College Teaching and Learning* (pp. 9-17). Jacksonville, FL: Florida Community College at Jacksonville.
- Berrett, D. (2012). How 'flipping' the classroom can improve the traditional lecture. *The chronicle of higher education*, 12.
- Brecht, H.D. (2012) Learning from Online Video Lectures, *Journal of Information Technology Education: Innovations in Practice*, 11.
- Cassidy, E. et al., (2014) Higher Education and Emerging Technologies: Shifting Trends in Students' Usage, *The Journal of Academic Librarianship* 40, pp. 124-133
- Gabel, D., Improving teaching and learning through chemistry education research: a look to the future. *Journal of Chemical Education*, 1999. 76 (4): p. 548-554
- Gellespie, R. (1997) The great ideas of chemistry. *Journal of Chemical Education*, 74 (7), p. 862.
- Guy, R., & Marquis, G. (2016). The flipped classroom: A comparison of student performance using instructional videos and podcasts versus the lecture-based model of instruction. *Issues in Informing Science and Information Technology*, 13, 1-13. Retrieved from <http://www.informingscience.org/Publications/3461>
- He, Y., Swenson, S., & Lents, N. (2012). Online video tutorials increase learning of difficult concepts in an undergraduate analytical chemistry course. *Journal of Chemical Education*, 89, 1128-1132.
- Law, N., & Chow, A. (2008). Pedagogical orientations in mathematics and science and the use of ICT. In N. Law, W. J. Pelgrum, & T. Plomp (Eds.), *Pedagogy and ICT use in schools around the world: Findings from the IEA SITES 2006 study* (pp. 121–179). Hong Kong: CERC and Springer.
- Lee, S. et al. (2011) Internet-Based Science Learning: A review of Journal Publications. *International Journal of Science Education* 33(14) pp. 1893-1925
- Robinson, W. (2004). Cognitive theory and the design of multimedia instruction. *Journal of Chemical Education*, 81(1), 10–12.
- Scheible, A., *Ist unser Chemieunterricht noch zeitgemäß?* MNU, 1969. 22 (8): p. 449
- Schmitt, F.J. et. al. (2015): *Targeted inversion, a case study*. Global Learn, April 2015 in Berlin, Germany Publisher: Association for the Advancement of Computing in Education (AACE).
- Schmitt, F.J., Schönemann, T., Kruse, F., Egbers, F., Delitzscher, S., Weissenborn, J., Aljanazrah, A. & Friedrich, T. (2015). *Targeted Inversion of the Tutorials in “Mathematics for Chemists”, A Case Study*. In Proceedings of Global Learn Berlin 2015: Global Conference on Learning and Technology (pp. 191-200). Berlin, Germany: Association for the Advancement of Computing in Education (AACE).
- Slavin, R., Lake, C., Hanely, P. & Thurston, A. (2014) Experimental Evaluations of Elementary Science Programs: A Best-Evidence Synthesis, *Journal of Research in Science Teaching* 51(7) pp. 870-901
- Tucker, B. (2012). The flipped classroom. *Education Next*, 12(1), pp. 82-83.
- Zahng, D. et al. (2006) Instructional video in e-learning: Assessing the impact of interactive video on learning effectiveness. *Information & Management* 43, pp.15–27.