IS IT WORTHWHILE TO FLIP? REFLECTING ON FLIPPED TEACHING IN CHEMICAL ENGINEERING

C.J. SCHABORT & G.M. REITSMA
NORTH-WEST UNIVERSITY

Abstract

The flipped classroom approach has been successfully implemented in a wide range of study fields. The use of the flipped classroom as part of a blended learning strategy in chemical engineering, however, is not a well-researched topic within the South African context. The question that now arises is: is it worthwhile for students and lecturers to spend so much time and effort on this approach in engineering education? This study aims to motivate the appropriateness of flipping the classroom in engineering education. For a group of third-year biotechnology students contact time was reduced and traditional lectures were replaced with audio PowerPoint slideshows, online tests and tutorials. The learning experience of these students was investigated by means of a survey, which showed that they experienced the flipped teaching approach positively and it did not impact negatively on overall student performance compared to other years. Changing to a flipped classroom enabled engineering students to work independently with audio-visual support material, reduced formal contact time and increased students' active involvement in class.

Keywords: chemical engineering, flipped teaching, engineering education, blended learning, student-centred learning, multimedia

1. INTRODUCTION

Considering the changing role of the university lecturer in the classroom over the last few years, the “Good-bye teacher...” anthem of Keller (1968, 79) resounds more clearly than ever before. By 1995, the idea of colleges as institutions of instruction had already started to move towards institutions of learning (Barr & Tagg, 1995, 13). Nowadays, universities are known for their high-impact educational practices (Kuh, 2008, 19) where active, engaged learning takes place (Michael, 2006, 160).

Brent & Felder (2009, 2) define active learning as an activity where all students are engaged with the course material, as opposed to the situation where students merely watch, listen or take notes. One of the aims of active learning is the participation of all students and not just the few students who always respond to questions in class (Brent & Felder 2009, 4). Over the last few years the flipped classroom approach has been implemented as part of a blended learning strategy.

Millard (2012) describes flipped classrooms as “learning spaces where lectures and other traditional classroom elements are swapped out in favour of more in-person interaction, like small group problem solving and discussion. Instead of being a central feature of a course, lectures are delivered outside of class via some type of streaming video, and students are expected to watch them on their own time”. In blended learning, physical and virtual environments are blended to support learning in university courses (Stacey & Gerbic, 2008). By moving some of the lecture material outside of the class, more class time can be made available for active learning (Getman *et al.,* 2014). However, active learning should be supported in both environments of blended learning.

The flipped classroom is a well-researched teaching approach. Even though there are some critics of this approach, the majority of lecturers who have implemented it experience an increase in active learning and a more engaged learning community (Enfield, 2013, 25). Both students and lecturers can testify to the myriad advantages associated with flipping the classroom. Not only can students work through the material at their own pace, but study material can be repeated until it is mastered. One of the main advantages of this approach is an improvement in student-lecturer interaction during contact sessions. As the lecturer circulates around the lecture hall, more one-to-one instruction can take place (Enfield, 2013, 26; Goodwin & Miller, 2013, 78-80; Roach, 2014, 76). It is also widely reported that in most cases, flipped teaching as a form of self-directed learning leads to an improvement in the overall performance of students (Michael, 2006, 165; Baepler *et al.,* 2014, 227, Chen *et al.,* 2014, 26; Roach, 2014, 75).

The flipped classroom has been successfully implemented in a wide range of study fields, including chemistry (Schneider *et al.,* 2014, 91; Baepler *et al.,* 2014, 227), computing and mathematical sciences (Simmonds *et al.,* 2014), economics (Roach, 2014, 75-76), history (Gaughan, 2014, 221-224), multimedia (Enfield, 2013, 14-29), nursing (Bristol, 2014, 43-46), nutrition (Gilboy, *et al.,* 2015, 109-114) and pharmacy (See and Conry, 2014, 585-588), to mention but a few. There are, however, only a few conference proceedings on this theme in the field of chemical engineering education and none within the South African chemical engineering context.

One of the crucial elements for successful flipped teaching is the support material developed for the out-of-class preparation. This material and the accompanying activities need to be well planned and developed as well as effective in “substituting” the lecturer and enabling the student to work independently. Cernusca & Forciniti (2011, 2576) evaluated the use of instructional videos in a thermodynamics course. These videos were well received by the students, but the study focused more on the videos than on the flipped classroom. Nicodemus *et al.* (2014a) also focused on screencasts in chemical engineering courses.

Although it is mentioned that these screencasts can be used as part of a flipped classroom strategy, the implementation thereof in the flipped classroom and the evaluation of the effectiveness of these screencasts in the flipped classroom were however not the focus of the study. Student feedback from the above study showed that 95% of students who made use of these screencasts considered them beneficial. Furthermore, 92% of students reported higher confidence with regard to understanding the material and 94% preferred the screencasts to textbooks (Nicodemus, *et al.,* 2014a).

Another study by Nicodemus, *et al.* (20140b) focused on the application of the flipped classroom in two chemical engineering courses, namely thermodynamics and material and energy balances. The classes were flipped by using the screencasts mentioned in their previous study (Nicodemus, *et al.,* 2014a), as well as suggested readings for students to complete before contact sessions. The effectiveness of the flipped classroom in these two chemical engineering courses was, however, not quantified. The initial feedback on the flipped package can be summarised as very positive, but no actual statistical figures were presented in the paper (Nicodemus, *et al.,* 2014b).

The purpose of this article is to describe the advantages of flipping a chemical engineering module based on students' learning experience and performance where the lecturer made use of electronic learning support material in the form of audio PowerPoint slideshows and audio PDF videos for the out-of-class teaching. In the first section of this article, the transformation from a traditional lecture-based form of teaching to a flipped classroom approach using specially developed videos is explained. This is followed by a description of the survey research conducted to determine students' experiences of the approach. In the third section of this paper, the results of the survey are presented and discussed, from which insights are shared in the form of guidelines and recommendations. The article concludes with a discussion of the limitations of this study, recommendations on how these limitations will be addressed in follow-up research, and recommendations for other lecturers who embark on the flipped classroom journey.

2. FROM TRADITIONAL TO FLIPPED

Before the classroom was flipped, the engineering students attended contact sessions where the lecturer described and discussed the theory using PowerPoint slideshows as visual aids. On average, a PowerPoint slideshow would comprise between twenty and thirty slides, which made it possible to cover the material in a single 50-minute contact session. The result was contact sessions that were mostly lecturer driven with limited student engagement in the form of questions and answers. The total contact time amounted to 8 hours per week, which included both theory and practical work.
To change the teaching approach to more student-centred active learning, the flipped classroom approach was implemented as part of a blended learning approach.

In the first instance, the teaching support material used in class was adapted to provide effective out-of-class learning support. The existing PowerPoint slideshows were subdivided into smaller slideshows consisting of a maximum of 10 slides per theme. Narration was then added to the smaller slideshows using the "Record Slide Show" function available in PowerPoint. The narrated slideshows were converted to video format and made available on an online platform. This process of screencasting allows the lecturer to record narrated presentations and produce them in video format for students to watch. Screencasts are specifically fitting for demonstrations or tutorials (Oomen-Early & Early, 2010, 102).

Secondly, contact time was significantly reduced from 8 hours of theory and practical classes to 3 hours of contact sessions in the form of tutorials, thus engaging students more actively in class. Prior to each week's tutorial contact sessions, students had to access the relevant videos on the online platform and complete an online test to ensure that the prescribed theory was studied. During the tutorial sessions, students participated in discussions that focused on the application of the theory, including case studies and the solving of practical problems. Table 1 provides an example of the teaching and learning approach implemented in the module:

Table 1: Example of the teaching and learning approach implemented in the module

Activity per week	Lecturer activity	Student activity
Tutorials In class F-2-F ± 3-4 hours	• Introduction to tutorial which is based on case studies and practical problems • Provide guidance and assistance to groups as they complete the given tutorial • Give individual feedback upon submission of the group's tutorial • Give general feedback to all students at the end of the tutorial session	• Completion of tutorial based on acquired knowledge *via* voice-over PowerPoint slideshows • Ask questions of the lecturer as the need arises • Peer evaluation of other groups
Homework Out-of-class Online ±4-5 hours	• Updating of voice -over PowerPoint slideshows should the need arise • Updating online tests from year to year • Create new voice -over Power Point slideshows on concepts that students may have difficulty with • General administration	• Work through voice-over PowerPoint slideshows while taking notes • Repeat voice-over PowerPoint slideshows until satisfactory level of understanding is reached • Complete online test based on the knowledge obtained in the voice-over PowerPoint slideshows

3. METHODOLOGY

3.1 Research design

A quantitative non-experimental design was used in which a survey was conducted to determine the learning experience of the population (MacMillan & Schumacher, 2014, 30-31). The survey included some qualitative data in the form of open-ended questions.

3.2 Population and sample

The population for the study consisted of all third year engineering students registered for the biotechnology (CEMI, 315) module in 2014. All students were invited to participate in the study, of whom 42 (69%) volunteered to complete the questionnaires. Informed consent was obtained from all the participants and the questionnaires were completed anonymously.

3.3 Measuring instrument

A questionnaire consisting of eight questions or statements focusing on students' experience of the electronic learning support material (audio PowerPoint videos) was developed. The questions consisted mainly of closed-ended questions, with two open-ended questions where students had to elaborate on their answers. The questionnaire was evaluated by an educational researcher for face validity and content validity. In addition to the questionnaire, three open-ended questions that were asked as part of the compulsory lecturer's evaluation (CLE) questionnaire at the end of the semester, as well as general comments made by the students during the CLE on the biotechnology course as a whole, were included in the study.

The Cronbach-Alpha coefficient of the questionnaire was calculated to be 0.75, which shows acceptable reliability and internal consistency.

3.4 Data collection and analysis

The students completed the questionnaires during the last week of the semester using an online, anonymous survey platform, after which descriptive statistics were applied. The CLE was completed in class without the lecturer present, according to the university procedures. Only the open-ended questions of the CLE that were specifically formulated with the aim of this research in mind were included in this study. The qualitative data were analysed from a deductive point of view, looking for themes that explain and clarify the quantitative results.

4. RESULTS AND FINDINGS

The results of the closed-ended questions are presented in Table 2. Questions 1 to 3 focused on the effectiveness of the PowerPoint videos with regard to reaching the outcomes of the biotechnology course. The ease and speed with which the module outcomes were reached in this course were compared to how outcomes were reached in other modules in chemical engineering that were still presented mainly in the traditional lecture format. Question 4 assessed the effectiveness of online tests prior to contact sessions. The last two closed-ended questions, questions 5 and 6, compared the teaching approach used in this biotechnology module to the teaching approaches used in other courses in chemical engineering. The aims were to determine students' preferences and also to obtain an indication of the current utilisation of flipped teaching in the engineering programme.

Table 2: Results of the survey questionnaire

	Number of students (% of class)			
	I agree completely	**I agree to a large extent**	**I don't agree completely**	**I strongly disagree**
1: The audio PowerPoint videos enabled me to work at my own pace.	38 (91%)	3 (7%)	0	1 (2%)
2: The audio PowerPoint videos helped me to acquire the outcomes of the module faster than normal lectures without supporting video material.	22 (52%)	17 (41%)	2 (5%)	1 (2%)
3: The audio PowerPoint videos helped me to acquire the outcomes of the module easier than normal lectures without supporting video material.	23 (55%)	19 (45%)	0	0
4: The online quizzes were effective in helping me master the outcomes of the study units.	13 (31%)	22 (52%)	7 (17%)	0
5: Audio PowerPoint videos (as used in Biotechnology I) or similar recordings are used in other chemical engineering modules.	0	1 (2%)	20 (48%)	21 (50%)
6. I would prefer that the theory part of all chemical engineering modules be presented in this fashion.	17 (41%)	24 (57%)	1 (2%)	0

The purpose of the two open-ended questions was to ascertain how concepts in the study material that were unclear were resolved (question 7) and whether PowerPoint videos or audio PDFs are the preferred method of instruction when bioengineering calculations have to be done (question 8). The three additional questions included from the CLE were:

- Now that we have reached the end of the semester, would you still prefer having the study units electronically available on eFundi and working through the work at your own pace, rather than having the traditional contact sessions (lectures)?
- What did you like about the way CEMI 315 was presented (flip teaching)?
- What did you not like about the way CEMI 315 was presented (flip teaching)?

The students experienced the audio PowerPoint videos as effective support material enabling them to study the theory independently from the lecturer. Nearly all the students (91%) agreed that the videos enabled them to work at their own pace (question 1). The fact that the material was recorded and made available online promoted self-directed learning. This finding was further supported by the general CLE feedback from the students:

> *"…as a student I can manage my own time as required. I have the study material to my disposal to make notes and summarise the work."*

> *"If I work at my own pace, I use my time more economically. I make summaries as I work through the videos, which saves time later."*

The majority of students agreed that they were able to reach the module outcomes faster (93%) and easier (100%) than with traditional lectures without the additional support material (question 2 and 3). However, some students (7%) felt that it did not necessarily help them achieve the outcomes faster. The feedback from the CLE had to be studied in order to understand the reasons behind this phenomenon. The students indicated that they would have preferred contact with the lecturer to be able to ask questions as they studied the theory, which would have been possible in the traditional lecture situation. However, since they had to work through the theory on their own, it may have taken them longer to understand it as they did not have help when they encountered a problem:

> *"I would prefer to have both contact sessions on the material and the videos. The recorded PowerPoint videos are excellent, but I miss the contact and explanation in person. This is especially problematic when it comes to problems. To try to figure these things out on your own is not so good."*

"If you do not understand something there is no one to ask for help and you must figure it out on your own."

This is, of course, one of the drawbacks of the flipped classroom, namely that questions cannot be directed immediately to the lecturer. The open-ended question 7 in the questionnaire was formulated with this expectation in mind: "If some concept was not clear in an audio PowerPoint video, how did you resolve it in most of the cases?" The responses to this question were categorised as follows: Google or other Internet search engine (38%); asked fellow students (31%); waited until the next contact session to ask the question (10%); wrote an e-mail to the lecturer (2%) and other (19%). Many students said that a combination of the given options was used, and it was also mentioned that the textbook was consulted. It should, however, be stressed that the majority of the class (93%) did not see the lack of immediate response from the lecturer as a major obstacle to mastering the material.

Online quizzes were specifically designed to scaffold self-study and support learning. The students had to complete the online quizzes as part of the evidence that they had worked through the theoretical components of the module before the tutorials. Although a large percentage of the students agreed completely (31%) and agreed to a large extent (52%) that the online quizzes helped them in mastering the outcomes, 17% of the students did not agree completely. The CLE comments did not provide any insight as to why these students felt that the online quizzes were not so helpful, and this aspect should be investigated further. One of the comments made by a student supported the purpose of these quizzes as scaffolding strategies:

"There have to be more deadlines. It was nice to have the quizzes. It forced you to go through the work in time."

In question 5, 98% of the students indicated that they had not experienced audio PowerPoint videos in any of the other modules in the chemical engineering programme. This is an indication that it is still a new and innovative approach to teaching in chemical engineering at the university where this study was conducted.

One other point of concern that was identified was the solving of practical problems. The presentation of theory in video format is not that difficult (and also preferred by 98% of the students as indicated in response to question 6), but when it comes to actual mathematically based problems, the PowerPoint videos are not that effective. This problem was addressed by making use of LivescribeTM. Audio PDFs, where the actual writing of the lecturer can be seen during the solution process, were recorded. In question 8 the students were asked which platform they prefer. The majority of students (67%) preferred the audio PDFs, while 7% of the students were content with either audio PDFs or PowerPoint videos.

It is important to note that in the case of theoretical content, the PowerPoint video will suffice, but when it comes to practical, mathematical problems, the preferred medium is one where the actual writing combined with the recorded explanation of the problem-solving process of the lecturer can be seen.

Lecturers may be concerned about what the effect of changing a teaching approach and decreasing contact time might be on the overall pass rate of students. Figure 1 shows the overall pass rate for the biotechnology course over five years. The traditional teaching method was used in the first three years and the flipped classroom approach in 2014 and 2015.

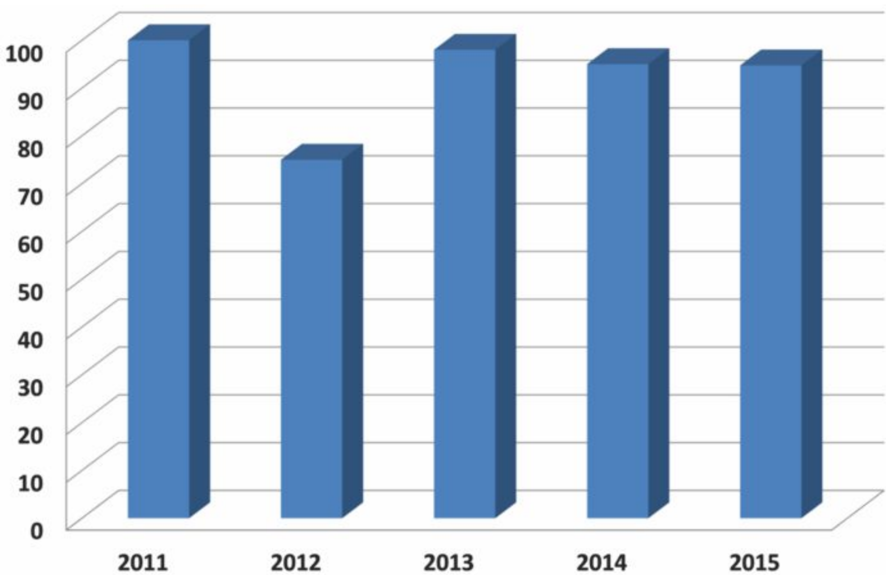

Figure 1: Student pass rate (%) in the biotechnology course over 5 years

There was no substantial change in the overall pass rate of the biotechnology course when the new teaching method was introduced. This means that the same pass rate can be achieved with almost five hours less contact time per week. The positive perception of the students is thus complemented by their performance in the subject.

5. DISCUSSION

This study set out to determine how engineering students experienced a flipped classroom teaching approach with specially designed audio PowerPoint videos used as learning support material for out-of-class learning. Contact time was reduced and classes were changed from lectures to tutorials.

The design and development of the learning support material plays a crucial role in supporting effective learning by students in the out-of-class environment. In engineering, problem solving through mathematical processes constitutes a major part of the curriculum. The challenge was to provide students with learning support material containing a step-by-step explanation of the problem-solving process, similar to what they would have received in the face-to-face contact sessions, so that they could understand and apply the mathematical processes themselves. However, voice-over PowerPoint videos were not effective in this regard. By using a program such as LivescribeTM, the lecturer was able to provide an audio-visual documentation of the problem-solving process, enabling the students to follow his actions and explanations step-by-step. A further advantage of this form of support material is that the students were able to see and hear their lecturer, even though they were not in class with him. Although Boyce (1999) cautions against the loss of contact between a lecturer and students with increased reliance on computers in teaching and learning, the form of teaching used in this study may limit the feeling of disconnectedness typically found in online learning.

Audio Powerpoint videos and PDFs, however, did not address the students' need to be able to ask the lecturer questions as they studied the work, an opportunity they would have had in face-to-face contact sessions. Students had to make do with other resources for help until they were able to communicate with the lecturer during the tutorials. It is advisable that the lecturer include some form of help desk or forum where students can post their questions online and receive explanations or answers before the tutorials.

A second element that contributed to the effectiveness of the learning support material was the re-design of the PowerPoint slides used in the traditional classroom, to shorter, more focused videos. Effective design of the learning support material, such as breaking the information into small packages, promotes the attainment of the learning outcomes (Halabi, 2006, 93). The students were able to engage better with the material in the short, 10 minute videos than they had with the lengthy PowerPoint slide shows. Similar results were found in other studies where multimedia lectures were recorded and made available online to students for viewing according to their own time schedule (O'Flaherty & Phillips, 2015, 85).

Another important advantage related to this method of teaching is that students do not need to multitask (and divide their focus) that much between various subjects. It has been proven that multitasking is a myth and the more students have to multitask, the lower their productivity (Medina, 2008). The normal timetable for chemical engineering students is packed with classes from 07:30 to 17:30. Students are required to switch constantly between various subjects on a single day, ranging from reactor theory to thermodynamics.

In the formal lecture-based timetable, students could only spend the short period of the contact session a certain topic before having to move on to the next class. With flipped teaching, students are able to focus on one subject in detail for a longer continuous time period, working at their own pace, before moving to another subject. This decreases the need for multitasking, helping the students to focus on a specific topic, and in this way increasing effective learning and productivity.

An important criterion for implementing a successful flipped classroom approach is that students should take responsibility for their learning, thus coming prepared to classes (Ravyse-Botha & Reitsma, 2015, 10). Compulsory online quizzes motivated the students to go through the work before attending the tutorial sessions, thus encouraging them to prepare. The online quizzes were designed in such a way that students received direct feedback on their performance as soon as they had completed the test. This process of effective and timely feedback promotes the attainment of learning outcomes (Halabi, 2006, 93). The online quizzes also provided a form of scaffolding, guiding the students through the different sections of the work, forcing them to complete each task, and providing them with feedback on their performance before they moved on to the next section.

One of the major benefits of the flipped approach is the decrease in contact time without loss of quality learning, as was found in this study. Not only did the students have more time to structure and manage their own learning, thus becoming less dependent on the lecturer, but the overall performance of the students compared well with that of previous cohorts.

The overwhelming majority of the students were positive about the flipped classroom approach in the biotechnology course. The results show that students can work at their own pace. Students experienced flipped teaching as a more focused approach and felt that outcomes were reached faster and easier compared to other subjects within chemical engineering where the flip teaching approach is not used. The fact that the material was recorded and made available online enabled self-directed learning. Students preferred moving the theory outside the classroom and using class time for knowledge application, a finding that was also referred to in a review published by O'Flaherty and Phillips (2015, 85).

6. CONCLUSION

Students experienced the flipped teaching approach positively and found that it helped them work more independently and in a self-directed manner. It also did not impact negatively on overall student performance compared to previous years. Changing from a traditional lecture approach to a flipped classroom enabled students to work independently with audio-visual support material, reduced formal contact time and increased students' active involvement in class.

These results hold important implications for engineering education as they show that this approach provides an effective alternative to traditional lectures without compromising student motivation and performance. Because this approach to teaching is still a new and somewhat unexplored area in the field of chemical engineering education, it should be researched further.

A limitation of this study was the small number of respondents for survey research, as data was only collected from volunteers from a single class. This study should be repeated in more engineering courses to determine the effectiveness of flipped teaching in other fields of engineering education.

7. RECOMMENDATIONS AND GUIDELINES

From this study, specific guidelines have been identified that can increase the effectiveness of flipped teaching in engineering and other disciplines. These recommendations can help other lecturers plan, design and implement a flipped teaching approach successfully, making it worthwhile for both the students and the lecturer.

- Shorten PowerPoint slideshow lectures: redesign the traditional lecture into shorter, 10-minute lectures, limiting the PowerPoint slides to less than 10 slides per session.
- Be present: use technology creatively to limit the feeling of disconnectedness that students may experience when working through material on their own. A program such as LivescribeTM enables lecturers to record their own writing and explanation of processes, enabling students to see and hear the lecturer as if they were in class.
- Provide a help desk: provide an additional platform such as an online forum where students can submit questions and receive guidance, not only from the lecturer but also from peers. This will ensure that students do not need to wait for the contact session when they need help.
- Scaffold learning: design structured activities such as online quizzes that will provide a form of scaffolding for learning. This will guide students to gain understanding of each section of the work before moving to the next section.
- Plan for extra time: prepare for the additional time needed to design and develop the out-of-class learning support material.
- Open feedback lines: if the opinions of students are regularly sought in the development of the flipped classroom, the overall experience for both lecturer and student is much more positive. The lecturer gets input from the student as “client” on a regular basis and is able to determine whether the changes that were implemented are actually a step in the right direction.

Students, on the other hand, feel that they can contribute positively in improving the overall learning experience by constructive criticism, not only for the current students, but also for future ones.

The results of this research could have a positive impact on teaching and learning practices in engineering education. The research provides hands-on guidelines on how lecturers can approach the transformation from a lecture-based form of teaching to a flipped classroom. The specific guidelines can be applied in any engineering classroom in order to facilitate student centred classrooms and to improve opportunities for in-person interaction through the implementation of flipped learning.

8. REFERENCES

Baepler, P., Walker, J.D. & Driessen, M. 2014. It's not about seat time: blending, flipping, and efficiency in active learning classrooms, *Computers & Education,* 78:227-236.

Barr, R.B. & Tagg, J. 1995. From teaching to learning – a new paradigm for undergraduate education. *Change,* 27(6):13-25.

Boyce, G. 1999. Computer-assisted teaching and learning in accounting. Pedagogy or product? *Journal of Accounting Education,* 17(2/3):191-220.

Bristol, T.J. 2014. *Educate, excite, engage. Teaching and Learning in Nursing,* 9:43-46.

Brent, R. & Felder, R.M. 2009. Active learning: an introduction. *ASQ Higher Education Brief*, 2(4).

Cernusca, D. & Forciniti, D. 2011. *Instructional videos with purpose: compensate, support, and challenge chemical engineering students in an introductory thermodynamics course.* In Proceedings of 118th ASEE Annual Conference & Exposition, Vancouver, Canada, 26 – 29 June 2011, 2576-2586.

Chen, Y., Wang, Y., Kinshuk, Chen, N. 2014. Is FLIP enough? Or should we use the FLIPPED model instead? *Computers & Education,* 79:16-27.

Enfield, J. 2013. Looking at the impact of the flipped classroom model of instruction on undergraduate multimedia students at CSUN. *TechTrends,* 57(6):14-27.

Gaughan, J.E. 2014. The flipped classroom in world history. *The History Teacher,* 47(2):221-244.

Getman, J., Khera, O., Kim, M.K. & Kim, S.M. 2014. The experience of three flipped classrooms in an urban university: an exploration of design principles. *Internet and Higher Education,* 22:37-50.

Gilboy, M.B., Heinerichs, S. & Pazzaglia, G. 2015. Enhancing student engagement using the flipped classroom. *Journal of Nutrition Education and Behavior,* 47(1):109-114.

Goodwin, B. & Miller, K. 2013. Evidence on flipped classrooms is still coming in. *Educational Leadership,* 70(6):78-80.

Halabi, A.K. 2006. Applying an instructional learning efficiency model to determine the most efficient feedback for teaching introductory accounting. *Global Perspectives on Accounting Education,* 3:93-113.

Keller, F.S. 1968. "Good-bye, Teacher..." *Journal of Applied Behaviour Analysis,* 1(1):79-89.

Kuh, G.D. 2008. *High-impact educational practices: what they are, who has access to them, and why they matter.* Washington, DC: Association of American Colleges and Universities.

Lai, C. & Kritsonis, W.A. 2006. The advantages and disadvantages of computer technology in second language acquisition. *National Journal for Publishing and Mentoring Doctoral Student Research,* 3(1):1-6.

McMillan, J. & Schumacher, S. 2014. *Research in education – evidence-based inquiry.* Essex UK: Pearson Education Limited.

Medina, J. 2008. *Brain Rules: 12 principles for surviving and thriving at work, home and school.* Seattle, WA: Pear Press.

Michael, J. 2006. Where's the evidence that active learning works? *Advances in Physiology Education,* 30(4):159-167.

Millard, E. 2012. *5 Reasons flipped classrooms work.* University Business, 15(11):26.

Nicodemus, G., Falconer, J.L., Medlin, W., McDanel, K.P., Anderson, C.R. & Senra, M. 2014a. *Screencasts for enhancing chemical engineering education.* In Proceedings of 121st ASEE Annual Conference & Exposition, Indianapolis, Indiana, 15 – 18 June 2014.

Nicodemus, G., Falconer, J.L., Medlin, W., De Grazia, J.L. & McDanel, K.P. 2014b. *Resources to implement flipped chemical engineering classrooms: Course Packages.* In Proceedings of 121st ASEE Annual Conference & Exposition, Indianapolis, Indiana, 15 – 18 June 2014.

O'Flaherty, J. & Phillips, C. 2015. The use of flipped classrooms in higher education: a scoping review. *Internet and Higher Education,* 25:85-95.

Oomen-Early, J. & Early, A.D. 2015. Teaching in a millennial world: using new media tools to enhance health promotion pedagogy. Pedagogy in Health Promotion: *The Scholarship of Teaching and Learning,* 1(2):95-107.

Ravyse-Botha, C. & Reitsma, G. 2015. Multi-media for flipped classrooms: engaged nutrition learning in a multi-media enhanced flipped classroom. *Progressio,* 37(1):1-14.

Roach, T. 2014. Student perceptions toward flipped learning: new methods to increase interaction and active learning in economics. *International Review of Economics Education,* 17:74-84.

Schneider, J., Munro, I. & Krishnan, S. 2014. Using audio-visual material to enhance laboratory practicals. *Journal of Teaching and Learning with Technology*, 3(2):91-93.

Stacey, E. & Gerbic, P. (2008). *Success factors for blended learning.* Paper presented at the 2008 Anual Acilite Conference, Melbourn: [Concise paper].

See, S. & Conry, J.M. 2014. Flip My Class! A faculty development demonstration of a flipped classroom. *Currents in Pharmacy Teaching and Learning,* 6:585-588.

Simmonds, T., Gent, D. & Stoneham, R. 2014. Effective/cost-effective screencasting. Compass: *Journal of Learning and Teaching,* 5(9).