Chapter

Flipped Classroom Approach of Teaching Chemistry in Higher Education

Kaouther Ardhaoui

Abstract

The flipping classroom method has been increasing steadily in acceptance and approval worldwide. In fact, there is a global agreement on the benefits of flipping courses at all levels and different majors. This approach has been largely adopted, specifically at the level of higher education. Our findings revealed an amelioration of the mean student's success percentage with the use of Edmodo and Moodle during the environmental chemistry course taught with the flipped approach. This paper reviews the flipped classroom method as an advantageous active learning method and counsels its combination with modern information and communication technology (ICT) for better profit as well.

Keywords: chemistry courses, higher education, flipped teaching, ICT

1. Introduction

According to Bonwell and Eison [1], the term "active learning" has never been specifically defined in educational researches and books. Some general features are usually related to the usage of policies that promote active learning in the class: Students' duty is not limited to listening. Low importance is given for transmitting information and much more on rising students' skills. Students are implicated in higher-order reflection (analysis, synthesis, and evaluation), and they are involved in activities (e.g., reading, discussing, and writing). A particular importance and consideration are bestowed on students' investigation of their own attitudes and standards.

Moreover, active learning is defined as any instructional method that engages students in the learning process [2]. The core elements of active learning are student activity and engagement in this learning process. Active learning is often contrasted to the traditional lecture, where students passively receive information from the instructor [2]. This strategy of active learning is generally adopted to improve Students' Critical Thinking, Performance, Creativity, Motivation, and Communication Skills [3–6]. Furthermore, Bonwell and Eison [1] stated that there is a Serious Problem in Higher Education which is described in eight perceptible discrepancies in the practice of higher education, counting the gap between teaching and learning, the gap between teaching and testing, and the gap between educational research and practice which were also acutely studied by Weinert et al. [7]. A thoughtful discrepancy also

occurs between how university educators typically teach (i.e., counting mainly on the lecture method) and how they intend and are supposed to teach (i.e., employing active learning to enable students' control of subject matter, improve academic capacities, and build personal perceptions and principles). Then there are solutions to abolish this discrepancy by adapting the lecture, performing more inspiring class discussions, and using other tactics related to active learning, such as blended teaching.

Essentially, this paper reports the important features of some reviews about flipped courses, especially chemistry courses at the level of higher education, in addition to modern techniques potentially useful to increase the benefits of flipping courses.

2. Presentation of the flipped course method

McNally et al. [8] identify a flipped classroom broadly, if events that have typically and traditionally happened inside the "classroom" (e.g., lectures) occurred outside the session. Crucial essentials of what founds a flipped classroom consist of (a) an opportunity for students to acquire introduction to study content before the class (e.g., recorded lectures), (b) an encouragement for students to prepare for class (e.g., pre-class quizzes), (c) a process to evaluate student understanding (e.g., graded pre-class quizzes), and (d) in-class activities that emphasize on higher-level cognitive activities including active learning, peer learning, and/or problem solving.

Additionally, the basic purpose of flipping the classroom is to relocate activities traditionally conducted within the classroom, like lectures, to educational resources that students engage with before attending class. This reallocation is intended to free classroom time to create meaningful learning situations for in-class interaction between students and teachers [9]. Also, Cheng et al. [10] define the flipped classroom instructional strategy as students learning with instructional supporting materials like documents or videos before class and then engaging in interactive and collaborative learning activities that facilitate their understanding, application, analysis, evaluation, and creation during class. Besides, O'Flaherty & Phillips confirm that students who are most profoundly involved will reflect, inquiry, speculate, estimate, and make links between ideas [11]. Otherwise, students who are disconnected seem to take a superficial method to learning by replicating transcripts, converging on disjointed evidences and hopping to deductions. During the flipped course, teachers and students have particular duties. In fact, Ozdamli & Asiksoy resumed and listed these roles as follows [12]:

3. Teacher's role

Create learning conditions based on direct questioning of knowledge, become a facilitator to promote learning, engage in one-on-one interactions with students, correct misunderstandings, personalize learning for each student, use technical equipment suitable for learning conditions, and create interactive discussions and conditions, increase student engagement, share lecture videos as extracurricular activities, provide feedback by applying teaching strategies.

4. Student's role

Take responsibility for their own learning, watch pre-class lecture videos and use learning materials to prepare for lessons, study at their own pace, interact with

teachers and friends as necessary, receive and give feedback, participate in class discussions, and participate in teamwork.

As regard to some confusions and misunderstandings of what flipped learning is, the Flipped Learning Network delivered the subsequent definition (Flipped Learning Network, 2014):

> *"Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space to the individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter" [13].*

5. Flipping courses in chemistry

Bodner stated that the principal learning theory in chemistry education is constructivism, which aims to base students' approach to learning, by absorbing new ideas and information so that it makes sense with what they already know [14]. Teaching underneath the sphere of constructivism would consequently mean that teachers do not just inform students what they are in need to acquire, but deliver structured activities so that they become able to build their knowledge within the strictures of their own prior knowledge [13]. Besides, Bergmann & Sams affirmed that flipping the classroom establishes a framework that ensures students receive a personalized education tailored to their individual needs [15]. Likewise, Bancroft et al. stated that numerous studies represent increasing evidence that flipping chemistry lecture courses have the potential to yield small to moderately significant gains in student academic performance compared to traditional lecture-based courses [16]. While studying the flipped classroom model in higher education, Al-Samarraie et al. revealed that chemistry was the foremost subject that profited from applying such approach. The flipped course was found to enable students' engagement and self-efficacy in studying by inspiring them to reflect on the topic and work with peers to answer questions and crack issues [17].

For example, in their evaluation of a flipped-format general chemistry course, Weaver and Sturtevant found that this teaching procedure increased student exam scores and passing rates [18]. In another study on organic chemistry, Fautch showed an improvement in the summative assessment of the students attending the flipped course with a noticeable gain in confidence and passion for the subject [19].

In our previous research [6], we found that flipped courses did not only improve achievement in a notable way, but they also boosted motivation levels. The likeliest explanation for this association between motivation and achievement is that increased motivation, the immediate reaction to a new learning task, is an affective state that involves feelings of arousal, alertness, attention, and concentration and is, therefore, a key initiator of productivity and achievement [20]. Our results were in line with subjective impressions: considering novel learning methods like flipped courses, revealed that these might be not only more motivating in comparison to classic courses, but also added that they might trigger knowledge acquisition. These outcomes are in agreement with those of Weaver and Sturtevant, who, after three years handling ACS (American Chemical Society) standardized exams, executed flipped courses and found that scores in the latter were significantly higher by almost one standard deviation when equated with students' preceding scores in conventional courses [18].

Our results agree, in an additional context, with a similar meta-analysis on the effects of flipped courses on learning results [21]. During this meta-analysis, the author established a strong positive impact of flipped courses and showed the definite potential of face-to-face time and quiz activities, which seem to configure the largest effect size.

6. Combining flipped courses with other technics

Observing the results' evolution of the achievement tests is related to the environment chemistry course that we have been teaching since 2018. We noticed a continuous improvement in the results of the students attending this course, where the flipped teaching techniques were considered, with the use of applications. In fact, during the university year 2018–2019, a flipped course with paper documents was taught, during the university year 2019–2020, a flipped course with numeric documents displayed on Edmodo was proposed, and during the university year 2019–2020, the same course was taught with Moodle where documents were displayed in addition to interactive activities. The mean student's success percentage was 74.2% in 2018; 77.3% in 2019; and 81.8% in 2020; such a result is likely to be due to the handling of ICT. This is in accordance with similar studies on the effect of modern technologies of communication on student grades. Actually, chemistry students' own smartphones, laptops, and tablets and could use appropriate apps to complement traditional forms of learning. There is a positive correlation between the relative grades obtained using mobile applications and the final exam grades [22]. Moreover, according to Guerrero et al., handling mobile applications in the lectures enthused not only collective work but also the use of mobile technologies for studying basic sciences [23]. In the laboratory, this technological skill abridged the average time of practices and led to an important reduction in reagent waste in the experiences as well as improved the number of successes regarding problem samples. In fact, interactive learning is one of the approaches, which is very important to explore in higher education. In addition, the use of modern computer software in educating chemistry makes the basis for rising students' curiosity in chemistry, delivering knowledge, and combining knowledge. Chemical computer software is a program intended to accomplish calculations of complex chemical equations and procedures, the structure of chemicals, their identification, and the presentation of the characteristics of various substances [24].

7. Discussion

Numerous studies have shown the advantages of using the flipped course approach in several disciplines, such as Hew et al.'s second-order meta-analysis of flipped classroom usage across subjects found that the flipped classroom approach improved overall academic performance compared to traditional non-flipped classrooms [25]. In a similar context, according to a systematic review performed by Akçayır and Akçayır, a reverse course leads to positive academic outcomes because it encourages improvement in student learning (e.g., enhanced motivation to learn, positive student attitudes) [26]. Recently, Jong reported that students from teaching subjects of language education, social and humanities education, and mathematics and science education, appreciated flipped courses as having desirable benefits for attention, relevance, and satisfaction, especially in chemistry teaching at the higher education level [27].

Meanwhile, some challenges and limitations were reported, related essentially to the lack of students' engagement in the extra class activities [11], the risk of being stubborn at the beginning and may come to class without preparation, and this approach is also seen as increasing rather than relieving teachers' responsibilities [12]. Consequently, some solutions are proposed in order to counter these issues, such as open teacher–student communication before flipping, showing students how to learn through flipped classrooms, and using gamified learning materials to monitor and motivate students' studying [28].

Additionally, using modern technologies like computers and applications raises the efficiency of teaching and the interest of students in learning. In fact, Ottenbreit-Leftwic et al. enlightened the results of surveys indicating that teachers use technology to address both majors (e.g., creating customized instructional materials, improving classroom management through student engagement) and student needs (e.g., improving student comprehension and equipping students with technology skills) [29]. Similarly, Ertmer & Ottenbreit-Leftwich proposed that teachers' mindsets must change to embrace the idea that teaching will not be effective without the appropriate use of information and communication technology (ICT) resources to facilitate student learning [30].

It is then advisable to combine the flipped course approach with modern technologies. In fact, the unified flipped learning model is wished for including the features of mobile and wireless communication technologies into the flipped classroom model to afford a director for researchers and educators to create operative flipped learning activities and plans for activating students' learning effortlessly across frameworks [31]. Furthermore, incorporating game elements into a flipped classroom increases motivation, participation, and learning performance. It is also found that the platforms, Moodle and Kahoot, are the most preferred platforms and points, badges, and leaderboards are the most used game elements for gamification [32]. Hence, the flipped course method is recommended in teaching chemistry courses in higher education, especially while combining this method with modern information communication technology.

8. Conclusion

This paper presents some eminent features of the advantages of adopting a flipped classroom approach, particularly during chemistry courses at the university, with a preference for joining this approach with modern technologies like computer and mobile applications. We found that combining applications like Edmodo and Moodle with the flipped course triggered better success percentages for students than paper-based flipped courses. Such a combination is now considered and generalized to all our courses where Moodle is used to teach chemistry flipped courses related to green chemistry, water treatment, and cosmetic formulation.

Author details

Kaouther Ardhaoui
Higher Institute of Applied Biology of Medenine, Arid Region Institute of Medenine, Research Laboratory of Eremology and Combating Desertification, University of Gabes, Gabes, Medenine, Tunisia

*Address all correspondence to: ardhaouikaouther@gmail.com

IntechOpen

References

[1] Bonwell CC, Eison JA. Active Learning: Creating Excitement in the Classroom. Washington, DC: George Washington Press; 1991

[2] Prince M. Does active learning work? A review of the research. Journal of Engineering Education. 2004;**93**(3): 223-231. DOI: 10.1002/j.2168-9830.2004.tb00809.x

[3] Kusumoto Y. Enhancing critical thinking through active learning. Language Learning in Higher Education. 2018;**8**(1):45-63. DOI: 10.1515/cercles-2018-0003

[4] Mora H, Signes-Pont MT, Fuster-Guilló A, Pertegal-Felices ML. A collaborative working model for enhancing the learning process of science & engineering students. Computers in Human Behavior. 2020;**103**:140-150. DOI: 10.1016/j.chb.2019.09.008

[5] Partanen L. How student-centred teaching in quantum chemistry affects students' experiences of learning and motivation—A self-determination theory perspective. Chemistry Education Research and Practice. 2020;**21**(1):79-94. DOI: 10.1039/C9RP00036D

[6] Ardhaoui K, Lemos MS, Silva S. Effects of new teaching approaches on motivation and achievement in higher education applied chemistry courses: A case study in Tunisia. Education for Chemical Engineers. 2021;**36**:160-170

[7] Weinert FE, Schrader F-W, Helmke A. Educational expertise. School Psychology International. 1990;**11**(3):163-180

[8] McNally B et al. Flipped classroom experiences: Student preferences and flip strategy in a higher education context. Higher Education (Dordr). 2017;**73**(2):281-298

[9] Lundin M, Bergviken Rensfeldt A, Hillman T, Lantz-Andersson A, Peterson L. Higher education dominance and siloed knowledge: A systematic review of flipped classroom research. International Journal of Educational Technology in Higher Education. 2018;**15**(1):20

[10] Cheng L, Ritzhaupt AD, Antonenko P. Effects of the flipped classroom instructional strategy on students' learning outcomes: A meta-analysis. Educational Technology Research and Development. 2019;**67**(4):793-824

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

[12] Ozdamli F, Asiksoy G. Flipped classroom approach. World Journal on Educational Technology: Current Issues. 2016;**8**(2):98-105

[13] Seery MK. Flipped learning in higher education chemistry: Emerging trends and potential directions. Chemistry Education Research and Practice. 2015;**16**(4):758-768. DOI: 10.1039/C5RP00136F

[14] Bodner GM. Constructivism: A theory of knowledge. Journal of Chemical Education. 1986;**63**(10):873

[15] Bergmann J, Sams A. Flip Your Classroom: How to Reach Every Student in Every Class Every Day. Washington, DC: International Society for Technology. in Education; 2012

[16] Bancroft SF, Jalaeian M, John SR. Systematic review of flipped instruction

in undergraduate chemistry lectures (2007-2019): Facilitation, independent practice, accountability, and measure type matter. Journal of Chemical Education. 2021;**98**(7):2143-2155

[17] Al-Samarraie H, Shamsuddin A, Alzahrani AI. A flipped classroom model in higher education: A review of the evidence across disciplines. Educational Technology Research and Development. 2020;**68**(3):1017-1051

[18] Weaver GC, Sturtevant HG. Design, implementation, and evaluation of a flipped format general chemistry course. Journal of Chemical Education. 2015;**92**(9):1437-1448. DOI: 10.1021/acs.jchemed.5b00316

[19] Fautch JM. The flipped classroom for teaching organic chemistry in small classes: Is it effective? Chemistry Education Research and Practice. 2015;**16**(1). DOI: 10.1039/C4RP00230J

[20] Ainley M. Connecting with learning: Motivation, affect and cognition in interest processes. Education in Psychological Review. 2006;**18**(4):391-405. DOI: 10.1007/s10648-006-9033-0

[21] van Alten DCD, Phielix C, Janssen J, Kester L. Effects of flipping the classroom on learning outcomes and satisfaction: A meta-analysis. Educational Research Review. 2019;**28**:100281-100299. DOI: 10.1016/j.edurev.2019.05.003

[22] Fonseca CSC, Zacarias M, Figueiredo M. MILAGE LEARN+: A mobile learning app to aid the students in the study of organic chemistry. Journal of Chemical Education. 2021;**98**(3):1017-1023

[23] Guerrero GE, Jaramillo CA, Meneses CA. Mmacutp: Mobile application for teaching analytical chemistry for students on qualitative analysis. In: 2016 International Conference on Interactive Mobile Communication, Technologies and Learning (IMCL). San Diego, CA, USA; 2016. pp. 50-54. DOI: 10.1109/IMCTL.2016.7753770

[24] Julboev TA, Sultonov MM, Abduvaliyeva K. Teaching Chemistry computer software to students of chemistry in pedagogical higher education institutions. European Journal of Research and Reflection in Educational Sciences. 2021;**9**(2):23-28

[25] Hew KF et al. On the use of flipped classroom across various disciplines: Insights from a second-order meta-analysis. Australasian Journal of Educational Technology. 2021;**37**(2):132-151. DOI: 10.14742/ajet.6475

[26] Akçayır G, Akçayır M. The flipped classroom: A review of its advantages and challenges. Computers in Education. 2018;**126**:334-345. DOI: 10.1016/j.compedu.2018.07.021

[27] Jong MS-Y. Flipped classroom: Motivational affordances of spherical video-based immersive virtual reality in support of pre-lecture individual learning in pre-service teacher education. Journal of Computing in Higher Education. 2022. DOI: 10.1007/s12528-022-09334-1

[28] Lo CK, Hew KF. A critical review of flipped classroom challenges in K-12 education: Possible solutions and recommendations for future research. Research and Practice in Technology Enhanced Learning. 2017;**12**(1):4

[29] Ottenbreit-Leftwich AT, Glazewski KD, Newby TJ, Ertmer PA. Teacher value beliefs associated with using technology: Addressing

professional and student needs. Computers in Education. 2010;**55**(3):1321-1335. DOI: 10.1016/j.compedu.2010.06.002

[30] Ertmer PA, Ottenbreit-Leftwich AT. Teacher TECHNOLOGY CHANGE. Journal of Research on Technology in Education. 2010;**42**(3):255-284

[31] Hwang G-J, Lai C-L, Wang S-Y. Seamless flipped learning: A mobile technology-enhanced flipped classroom with effective learning strategies. Journal of Computers in Education. 2015;**2**(4):449-473

[32] Ekici M. A systematic review of the use of gamification in flipped learning. Education in Information Technology (Dordr). 2021;**26**(3):3327-3346