A flipped classroom model in higher education: a review of the evidence across disciplines

Al-Samarraie, H., Shamsuddin, A. & Alzahrani, A. I.

DOI 10.1007/s11423-019-09718-8
ISSN 1042-1629
ESSN 1556-6501

Publisher: Springer

The final publication is available at Springer via http://dx.doi.org/10.1007/s11423-019-09718-8

A flipped classroom model in higher education: A review of the evidence across disciplines

Abstract

The recent movement to integrate the flipped classroom model into the system of higher education has resulted in significant changes that affected both teaching and learning practices in many contexts. After almost a decade of research on the flipped classroom model, different emergent outcomes have been reported in a domain specific context. To gain a comprehensive understanding of the flipped classroom implementation in a university context, a review of the literature on the use of flipped classroom in a university context was conducted. This study was guided by interpreting the previous research findings according to the domain of utilization, opportunities, challenges, and extensions to the conventional flipped classroom model. This study found that the utilization of flipped classroom in various disciplines is mainly advocated to promote students' engagement, metacognition, attitude, performance, understanding, and achievement, as well as other learning outcomes. The key challenges of this method, shared across all disciplines, were devoted to the length of the video/digital materials and time required for instructors to prepare the learning materials and for students to master it. Recommendations for policy makers and other crucial insights for the future studies were highlighted.

Keywords: *improving classroom teaching, teaching/learning strategies, lifelong learning*

1. Introduction

The concept of learning continues to evolve from time to time especially with the utilization of various teaching and learning strategies for the promotion of students' learning and autonomy (Al-Samarraie & Saeed, 2018). This is evident from the continued emphasis of educational policy, which focuses on ensuring that both students and instructors are equipped with the most effective instrumentation essential for facilitating communication. In a university context, students are expected to engage in the course material regularly with minimal support from the instructor (Baragash & Al-Samarraie, 2018a & b; Andreasen, Kotler, & Parker, 2003; Zeichner, 2010). This is where flipped/inverted classroom is used as a solution, mainly, to take the lecture from in-class time and move it to pre-class preparation so that in-class time could be maximized for active learning activities.

Flipped classroom as a model requires students to take charge of their learning and decisions during pre-class, in-class, and post-class (Prust, Kelnhofer, & Petersen, 2015). The knowledge obtained from each phase is used to promote students' reflection and communication throughout the learning process. Students in the 'pre-class' phase are expected to engage with the learning materials provided by the instructor to obtain the necessary exposure of the 'in-class' phase, where they are provided with a set of learning activities such as discussion and group presentation with minimal support from the instructor. Then, in the 'post-class' phase, students are exposed to different assignments or quizzes as an enrichment activity for strengthening their knowledge gained from the previous phases. The outcomes resulted from these learning phases have motivated several previous studies to validate the potential of flipped classroom in different learning contexts (Gong et al., 2018; McLean & Attardi, 2018). This is basically because the common belief about the flipped classroom model is that it offers students meaningful learning experiences by enabling them to link between the new and prior knowledge in order to overcome conceptual challenges in a domain-specific context (Yilmaz & Baydas, 2017).

However, previous reviews on flipped classroom effectiveness and utilization in higher education (e.g., Bishop & Verleger, 2013; DeLozier & Rhodes, 2017; O'Flaherty & Phillips,

2015) offer a limited depth of evidence regarding the opportunities (e.g., offering time flexibility, interacting collaboratively with peers, engaging in higher-order cognition, etc.) of flipped classroom in stimulating certain learning outcomes. According to Bishop and Verleger (2013), the utilization of flipped classroom across learning domains may imply different outcomes for students or change the cohort format of the class. In addition, applying the flipped classroom model may result in customization of learning materials that do not impose pedagogy or quality criteria (Graham, Henrie, & Gibbons, 2014). With the growing number of educators designing and implementing the flipped classroom model as a means for improving students' learning outcomes, there is a notable lack of evidence-based best practices for the application of flipped classroom in higher education (Betihavas, Bridgman, Kornhaber, & Cross, 2016; Khanova et al., 2015). Hence, this study reviewed previous works on the use of flipped classroom approach in a university context. Precisely, a demonstration of the effects of flipped classroom on students' learning in various university disciplines was provided. This study also listed the current extensions to the flipped classroom model, along with the key opportunities and challenges, in order to reach a generally acceptable conclusion about the potential of this method in a university context.

Flipped classroom in this study refers to the full utilization of the model phases as shown in Figure 1 where students are provided with video/digital media lessons before class to gain first exposure to the learning materials. In addition, students involved in the flipped classroom process must have had an opportunity to complete assignments/quizzes before or at the start of class. Finally, instructors must guide and provide answers to students' questions through in-class sessions, as well as allowing them to collaborate with each other to practice and apply the learning materials received prior to the class.

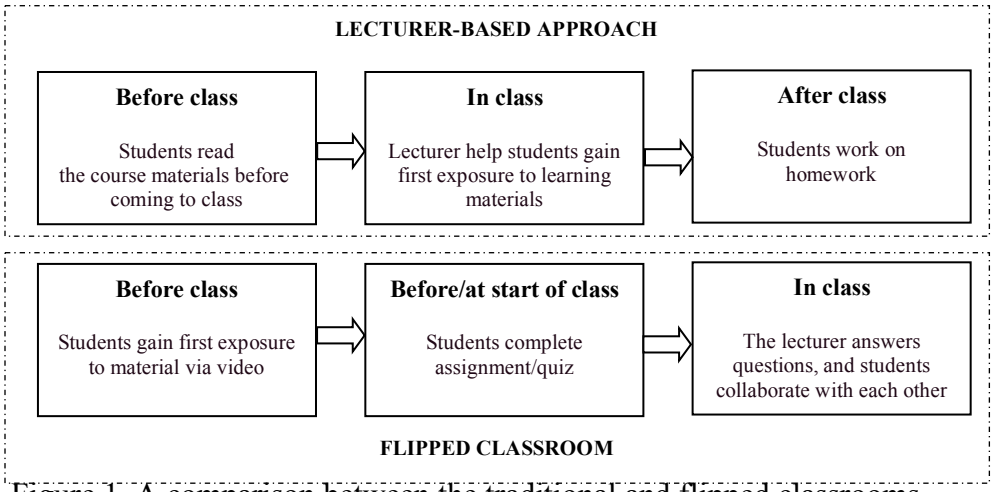

Figure 1. A comparison between the traditional and flipped classrooms

A number of systematic review articles have been published within higher education focusing on various important topics. For example, Betihavas et al. (2016); Tan, Yue and Fu, (2017) conducted a systematic review on the role of flipped classroom in nursing education. Chen, Lui, and Martinelli (2017) reviewed the literature on the effectiveness of flipped classroom in medical education. Another review was conducted by Karabulut-Ilgu, Cherrez, and Jahren (2018) in engineering education. Despite these reviews, there is a lack of review studies with focus on investigating the impact of flipped classroom on students' learning across disciplines. Since flipped classroom has become an important focus of both instructors and educational policy makers (Giannakos, Krogstie, & Sampson, 2018), it seems appropriate to address this research gap.

2. Methodology

This study was undertaken to answer three research questions: 'What is the effect of using flipped classroom on students' learning across university disciplines?' 'What are the opportunities and challenges from using the flipped classroom model in these disciplines?', and 'What are the major extensions to the traditional flipped classroom model?' Based on a wide-ranging review of existing survey in higher education, this study can be used to provide an in-depth understanding and form an integral view of the main aspects related to the use of flipped classroom in higher education. This includes identifying the classification elements relevant to the research questions, as recommended by Searcy and Mentzer (2003); Chugani, Kumar, Garza-Reyes, Rocha-Lona and Upadhyay (2017); Al-Samarraie and Hurmuzan (2018). According to these studies, the process of analysis contains four steps:

1) Defining unit of analysis: the unit analysis has been defined as a single research article or thesis. The materials were further delimited as per the scope and relevance to the context of higher university.
2) Classification context: previous studies were classified according to discipline or domain (e.g., engineering, language, arts, etc.) (Egger, Dickersin, & Smith, 2001; Khan, Kunz, Kleijnen, & Antes, 2003) in order to provide a better understanding of how the flipped classroom model can be used to promote students' learning.
3) Then, the effects of flipped classroom on students' learning outcomes in each discipline were reported along with the major opportunities and challenges. Other extensions to the traditional flipped classroom model were also examined in this study.
4) Material evaluation: the materials used to identify the major aspects of this study were analyzed and sorted according to the proposed classification context. Certain keyword combinations were used: 'flipped classroom' OR 'flipped classroom OR 'flipped model' OR 'flipped learning' OR 'flipped approach' OR 'flipped environment' OR 'flipped teaching' AND 'university learning/context' OR 'higher education' OR 'university students' OR 'undergraduate/postgraduate students'. Five main databases were used to search for articles based on these keyword combinations. Google Scholar, NREL, Science direct, and Web of Science. The extracted articles were confirmed according to some selection criteria suggested by previous reviews (e.g., Beelmann, 2006; Kitchenham, 2004) related to the language of research and research design. This is due to the lack of resources and time available for translation, and the need for clues about the flipped classroom effect that this study is aiming to review.
5) Collecting publications and delimiting the field: the review of the literature in this study was typically devoted to studies published in peer-reviewed journals, conference proceedings, and book publishers. To establish a time span, a starting point was set at 2009.

A total of 1621 articles from different databases were extracted; however, only 195 articles were found to meet our inclusion criteria: written in English, and validated by at least one research design (qualitative/quantitative) to assess factors hypothesized to predict, influence or explain individuals' learning outcomes in a university context. The initial screening result performed by the researchers led to the inclusion of 93 papers. Subsequently, retained full-text articles were further screened by the researchers based on the same two inclusion criteria utilized during screening of the article records with an additional criteria that the flipped classroom model is fully defined and utilized (previous studies that partially used the flipped classroom model were not included). As such, seven articles that used flipped classroom partially along with other methods were excluded from this study (see Figure 2).

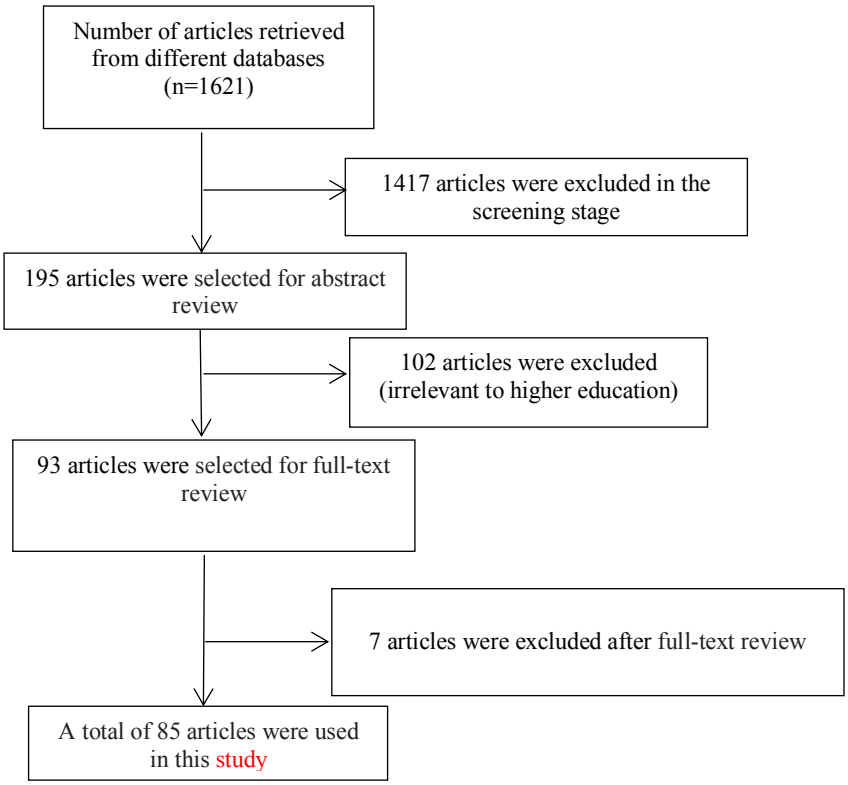

Figure 2: The selection of previous studies

2.1 Quality assessment

The quality of the 85 articles was assessed by three experts (score from 1-3, low-high) based on; 1) appropriateness of the research description in terms of topic and measures used 2) appropriateness of the methods and analysis used for answering the research questions 3) relevance to the context of focus and 4) whether the findings are credible and transferable. The weight of each article was assessed based on the available evidence calculated by summing scores on each of the four dimensions. The inter-rater reliability (r) result obtained for all articles was 0.87, showing good agreement between the three experts regarding the quality of the selected articles. Articles that received medium and high scores were considered in this study, leaving us with only 85 solid articles used in constructing this study.

3. Results

The distribution of the 85 studies (see Figure 3) was mainly across seven disciplines: Engineering and technology (16.2%); Mathematics (9.4%); Medical and health sciences (23.5%); Natural sciences (20%); Social sciences and humanities (20%); Education (8.2%); and Arts (3.5%). The result from reviewing these studies showed how the flipped classroom model can be used in teaching and learning across university disciplines. This includes identifying the main opportunities and challenges from using the flipped classroom model in these disciplines.

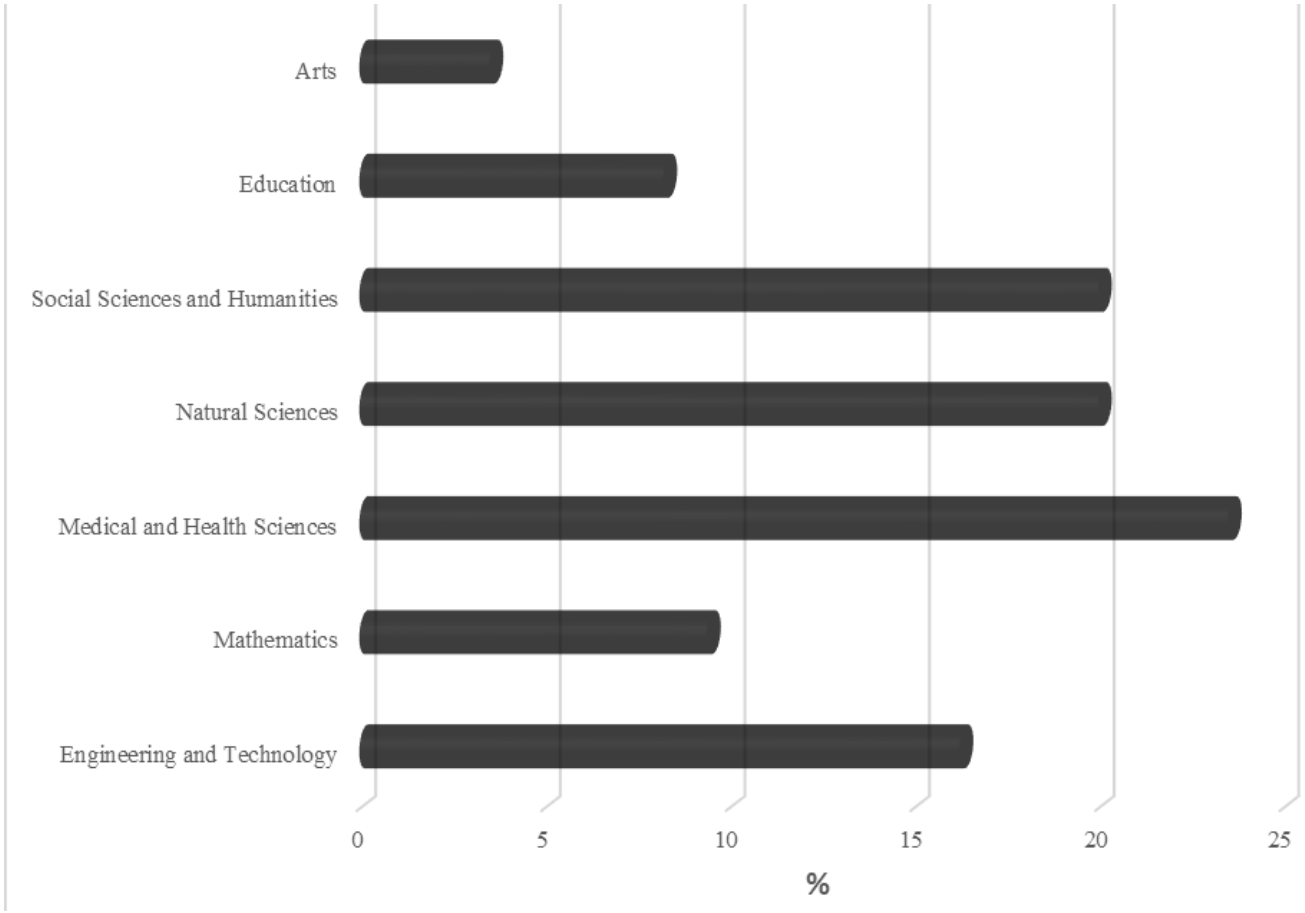

Figure 3: Distribution of previous studies on flipped classroom across disciplines

Table 1 presents a chronological (2009-2018) list of studies that were included in this study. These studies were presented based on the purpose of using flipped classroom, discipline of the study, and outcomes. The following sub-sections describes the application of flipped classroom in these disciplines.

Table 1
A comparison between previous studies on flipped classroom in higher education

No.	Author (Year)	Purpose	Discipline	Outcomes
1	Zappe, Leicht, Messner, Litzinger, and Lee (2009)	Examined the role of flipped classroom in the teaching of engineering subjects.	Engineering and Technology	Active learning in the flipped classroom session improved students' understanding.
2	Toto and Nguyen (2009)	Implemented flipped classroom in an industrial engineering course.	Engineering and Technology	Students' perception was positive among the majority of students.
3	Pierce and Fox (2012)	Investigated the impact of the flipped classroom model on pharmacy students' performance and attitudes.	Medical and Health Sciences	Students' performance was improved along with their perceptions about the instructional approach.
4	Strayer (2012)	Compared the learning in the flipped classroom introductory statistics class with a traditional introductory statistics class.	Mathematics	Students in the flipped classroom session were less satisfied with how the classroom structure oriented them to the learning task.
5	Tune, Sturek, and Basile (2013)	Studied the effectiveness of a traditional lecture-based curriculum versus flipped classroom.	Medical and Health Sciences	Students scored significantly higher than those who attended the traditional class.
6	Enfield (2013)	Studied the potential of implementing flipped classroom as an instructional method.	Arts	The flipped classroom model increased students' self-efficacy to learn independently.
7	Amresh, Carberry, and Femiani (2013)	Studied the impact of flipped classroom on students' self-efficacy and performance.	Engineering and Technology	Students' performance score and computing self-efficacy were improved.
8	Wilson (2013)	Examined the use of flipped classroom through structural and procedural changes to an undergraduate statistics course.	Mathematics	The flipped classroom model influenced students' learning performance.
9	McLaughlin et al. (2013)	Investigated the effect of the flipped classroom model on students' academic performance, engagement, and perception.	Medical and Health Sciences	No significant differences in students' performance were found when using the flipped classroom model and the traditional classroom.
10	Davies, Dean, and Ball (2013)	Explored the benefit of flipped classroom in teaching spreadsheet course.	Mathematics	No significant differences in students' achievement when using the flipped classroom approach and the regular approach.
11	Missildine, Fountain, Summers, and Gosselin (2013)	Studied the effects of flipped classroom and innovative learning activities on academic success.	Medical and Health Sciences	Students were less satisfied with the use of flipped classroom.
12	Mason, Shuman, and Cook (2013)	Compared traditional and flipped classroom in areas related to content coverage, student performance, and student perception.	Engineering and Technology	The flipped classroom model enabled the students to perform better in quizzes and exam.
13	Phillips and Trainor (2014)	Examined the use of flipped classroom in teaching accounting to the millennial generation of students.	Social Sciences and Humanities	The flipped classroom model improved students' attitude towards the course.
14	McLaughlin et al. (2014)	Investigated the impact of the flipped classroom model on engagement and performance of students in basic	Medical and Health	The flipped classroom model increased students' performance and engagement.

		pharmaceutics course.	Sciences	
15	Roach (2014)	Studied the implementation of flipped classroom in microeconomics course.	Social Sciences and Humanities	Students' perception to learn with the flipped classroom course was positive.
16	Wong, Ip, Lopes, and Rajagopalan (2014)	Assessed the impact of flipped classroom on academic performance and student perceptions.	Medical and Health Sciences	The flipped classroom model improved students' examination scores and satisfaction.
17	Triantafyllou and Timcenko (2014)	Examined the effect of flipped classroom on deep and creative discussions.	Mathematics	The flipped classroom model significantly improved students' performance.
18	Brooks (2014)	Conducted a pilot study of student learning and perceptions pertaining to flipped classroom and usual class.	Social Sciences and Humanities	There were no significant differences in students' learning when using the traditional method and the flipped classroom model.
19	Murray, McCallum, and Petrosino (2014)	Compared outcomes of students who were exposed to flipped classroom versus traditional classroom.	Medical and Health Sciences	No significant differences in students' performance when using the flipped classroom approach and the traditional method.
20	Fraga and Harmon (2014)	Examined the impact of flipped classroom on students' achievement.	Education	Students' learning was the same when using the flipped classroom and the traditional classroom-based instruction.
21	Kurtz, Tsimerman, and Steiner-Lavi (2014)	Reported students' perceptions of flipped classroom for teaching business classes.	Social Sciences and Humanities	The flipped classroom model increased students' involvement in learning, understanding, and confidence were increased.
22	Moffett and Mill (2014)	Assessed the use of flipped classroom within a medical education setting.	Medical and Health Sciences	Students in the traditional classroom outperformed students in the flipped classroom.
23	Schwartz (2014)	Investigated the effect of flipped classroom on students' active learning practices.	Medical and Health Sciences	The flipped classroom model supported nursing students' learning.
24	Vaughan (2014)	Examined the use of flipped classroom to promote students' reflection and inquiry in the course.	Education	The flipped classroom model enabled students to process higher level of reflection and inquiry.
25	Teo, Tan, Yan, Teo, and Yeo (2014)	Examined students' engagement in the flipped classroom for promoting their self-directed learning outside the classroom.	Natural Sciences	The flipped classroom model helped students in understanding the theory construction process.
26	Wanner and Palmer (2015)	Investigated students' perception about flexible learning and flipped classroom.	Social Sciences and Humanities	Students differently perceived the use of flipped classroom.
27	Whillier and Lystad (2015)	Evaluated the effectiveness of flipped classroom in the intensive mode classroom.	Medical and Health Sciences	The results showed no significant differences in students' final grades, self-rated knowledge, or overall satisfaction when using the flipped classroom and the traditional classroom.
28	Harrington, Bosch, Schoofs, Beel-Bates, and Anderson (2015)	Studied the effect of flipped classroom and traditional classroom on students' exam grades.	Medical and Health Sciences	There were no significant differences in students' learning with and without flipped classroom.
29	McCallum, Schultz, Sellke, and Spartz (2015)	Examined the impact of flipped classroom on students' involvement.	Mathematics	Student academic involvement in flipped classroom was improved with note taking, viewing video lectures, active in-class learning and collaboration.

30	Prashar (2015)	Examined students' perception towards the flipped classroom.	Social Sciences and Humanities	Students in the flipped classroom environment learned better than the conventional and lecture-oriented environments.
31	Ryan and Reid (2015)	Investigated the effect of flipped classroom on students' performance and retention.	Natural Sciences	No difference in students' exam performance when using flipped classroom and the traditional classroom.
32	Velegol, Zappe, and Mahoney (2015)	Investigated the effect of flipped classroom on students learning of environmental engineering subject.	Environmental Engineering	The flipped classroom model facilitated students' learning through a variety of activities such as problem solving, guest speakers, idea generation, and field trips.
33	Gross, Pietri, Anderson, Moyano-Camihort, and Graham (2015)	Examined the impact of flipped classroom on students' performance in physical chemistry course.	Natural Sciences	The flipped classroom model improved students' exam performance.
34	Tanner and Scott (2015)	Studied the effect of flipped classroom on students' learning of analysis and design.	Social Sciences and Humanities	The flipped classroom model influenced students' attitude to learning and use of design strategies.
35	Mattis (2015)	Assessed the accuracy of flipped classroom versus a traditional classroom at three levels of mathematical complexity.	Mathematics	The flipped classroom model increased students' learning accuracy and mental effort.
36	Van Vliet, Winnips, and Brouwer (2015)	Studied the effects of flipped classroom on students' motivation and learning in higher education.	Natural Sciences	The flipped classroom model enhanced student metacognition and collaborative-learning strategies.
37	Simpson and Richards (2015)	Studies the use of flipped classroom to re-design a population health subject in Midwestern nursing program.	Medical and Health Sciences	The flipped classroom approach offered an engaging experience for students and better understanding of the content in a nursing curriculum.
38	Jensen, Kummer, and Godoy (2015)	Compared students' outcomes when using flipped classroom and traditional classroom.	Natural Sciences	No significant differences in learning gains and attitudes among students who used flipped classroom and the traditional classroom.
39	Mzoughi (2015)	Analysed students' engagement in flipped classroom and its correlation with their performance level.	Natural Sciences	The flipped classroom model increased both students' engagement and performance.
40	Hotle and Garrow (2015)	Compared the impact of flipped classroom verses the traditional classrooms in an undergraduate civil engineering course.	Engineering and Technology	No significant difference in students' performance when using flipped classroom and the traditional classroom.
41	Evseeva and Solozhenko (2015)	Investigated the effect of flipped classroom on students' learning of English language.	Social Sciences and Humanities	The flipped classroom model enhanced students' motivation and improved their academic performance.
42	Al-Zahrani (2015)	Examined the impact of flipped classroom on students' creative thinking.	Education	The flipped classroom model promoted students' creativity through fluency, flexibility and novelty.
43	Hung (2015)	Investigated the potential of flipped classroom in language classrooms.	Social Sciences and Humanities	The flipped classroom enhanced students' learning outcomes and developed better attitudes toward their learning experiences.
44	Jungić, Kaur, Mulholland, and Xin (2015)	Studied how flipped classroom can stimulate students' engagement in calculus courses.	Mathematics	The flipped classroom model stimulated students' engagement with the course.
45	Yestrebsky (2015)	Studied the effectiveness of flipped classroom for freshmen chemistry classes.	Natural Sciences	The performance of students was increased when using flipped classroom as compared to the traditional classroom.
46	Tawfik and Lilly (2015)	Examined the implementation of flipped classroom in a	Mathematics	The flipped classroom model promoted learners' positive perception, efficacy,

		psychological statistics course.		and directed learning to better understand the content.
47	Danker (2015)	Used flipped classroom to stimulate deep learning (understanding) in large classroom during teaching of a film module.	Arts	Students' abilities to connect new and previous knowledge were improved with flipped classroom.
48	Gilboy, Heinerichs, and Pazzaglia (2015)	Illustrated the potential of flipped classroom in two undergraduate nutrition courses.	Medical and Health Sciences	Students' perception of learning was positive where the flipped classroom was used to enable them engage in new, more meaningful ways of learning.
49	Belfi, Bartolotta, Giambrone, Davi, and Min (2015)	Examined the effectiveness of flipped classroom in teaching radiology.	Medical and Health Sciences	The flipped classroom model improved students' knowledge of the course.
50	Simpson and Richards (2015)	Compared the impact of flipped classroom versus traditional classroom to population health content.	Medical and Health Sciences	No statistically significant differences in the university course evaluations between the traditional classroom and flipped classroom.
51	Hao and Lee (2016)	Investigated students' personal characteristics and concerns about teaching with the flipped classroom.	Education	The flipped classroom model increased learners' self-efficacy and knowledge.
52	Porcaro, Jackson, McLaughlin, and O'Malley (2016)	Studied the effect of changing the delivery mode (from the traditional model to flipped classroom) on students' perceptions and outcomes.	Medical and Health Sciences	The flipped classroom improved students' learning outcomes and stimulated positive perception towards the course.
53	Zainuddin and Attaran (2016)	Studied the impact of flipped classroom on students' perceptions and feedback.	Education	The flipped classroom model promoted students' positive perceptions towards the course.
54	Koo et al. (2016)	Investigated the effect of flipped classroom versus traditional classroom on students' performance and perceptions.	Medical and Health Sciences	The flipped classroom model improved student test performance and perceptions of the learning experience.
55	Peterson (2016)	Examined students' achievement and satisfaction with flipped classroom in a statistics course.	Mathematics	The flipped classroom model helped in improving students' achievement and satisfaction.
56	Foldnes (2016)	Studied the effect of flipped classroom versus traditional classroom to encourage cooperative learning.	Social Sciences and Humanities	No significant differences in students' learning when learning with the lecture classes and the flipped classroom.
57	Hanson (2016)	Examined nursing students' perceptions of flipped classroom effectiveness for understanding pharmacology principles.	Medical and Health Sciences	Students' understanding was improved in the flipped classroom session.
58	Blair, Maharaj, and Primus (2016)	Studied the potential of flipped classroom in improving the learning experience in relation to exam performance and student perception.	Material Technology	No significant differences in relation to average cohort exam performance were found among students in the traditional classroom and the flipped classroom.
59	Liebert, Lin, Mazer, Bereknyei, and Lau (2016)	Studied the impact of flipped classroom versus traditional didactic lectures to teach surgery clerkship.	Medical and Health Sciences	No difference between mean scores in the traditional classroom and the flipped classroom.
60	Yestrebsky (2016)	Investigated the effectiveness of flipped classroom implementation to improve students' final grades.	Natural Sciences	The flipped classroom model enabled students to achieve high grades as compared to the traditional classroom.
61	Casadonte (2016)	Investigated the impact of flipped classroom on students' performance in standardize exams.	Natural Sciences	Significant improvement in students' performance was found after attending the flipped classroom environment.

62	Haak and Burand (2016)	Examined the potential of flipped classroom for increasing students' success and improving learning outcomes.	Natural Sciences	Students' performance in the flipped classroom was increased.
63	Lekhi and Nashon (2016)	Examined the potential of flipped classroom for promoting transformations in students' personal epistemologies.	Natural Sciences	The flipped classroom model facilitated the development of sophisticated epistemology (knowledge) among students.
64	Maloney (2016)	Investigated the use of the flipped classroom format in improving students' performance.	Natural Sciences	Students' performance in the flipped classroom excel better than students in the traditional classroom.
65	Muth (2016)	Studied the effect of flipped classroom in teaching biochemistry on students' learning and communication.	Natural Sciences	Students' exam results were improved with the flipped classroom.
66	Soult (2016)	Examined the use of flipped classroom in promoting students' problem solving.	Natural Sciences	The flipped classroom model encouraged students to think about the topic and work with others.
67	Esson (2016)	Addressed the development and assessment of flipped classroom in chemistry courses.	Natural Sciences	The flipped classroom model promoted students' engagement and self-efficacy in learning.
68	Ojennus (2016)	Investigated the effect of flipped classroom versus traditional classroom on students' perception and performance.	Natural Sciences	No significant differences in students' performance when using the flipped classroom and the traditional classroom.
69	Sohrabi and Iraj (2016)	Studied the use of flipped classroom in two big data courses.	Social Sciences and Humanities	Students positively perceived the use of flipped classroom.
70	Goss (2016)	Examined students' perceptions towards the flipped classroom.	Natural Sciences	The flipped classroom model improved students' conceptual understanding of the subject matter.
71	Pardo and Mirriahi (2017)	Investigated how flipped classroom experience promote students' learning of engineering subjects.	Engineering and Technology	Students' engagement was sustained through the implementation of flipped classroom in the classroom.
72	Panuwatwanich (2017)	Demonstrated an actual design and implementation of flipped classroom among engineering students.	Engineering and Technology	The flipped classroom model enabled students to apply relevant knowledge within a controlled environment.
73	Wright, Greenfield, and Hibbert (2017)	Reported on the use of flipped classroom intervention in an undergraduate business course.	Social Sciences and Humanities	The flipped classroom approach promoted students' motivation, engagement, and performance.
74	Clark, Clark, and Besterfield-Sacre (2017)	Assessed the flipped classroom effectiveness in promoting active learning and engagement among students.	Engineering and Technology	The flipped classroom model promoted active learning in the classroom by engaging students in self-learning and deeper learning experiences.
75	Chen Hsieh, Wu, and Marek (2017)	Investigated the effect of flipped classroom on students' motivation and knowledge of English.	Social Sciences and Humanities	The flipped classroom model enhanced students' motivation in the classroom.
76	McCredden, Reidsema, and Kavanagh (2017)	Investigated the effect of the flipped classroom approach on students' academic knowledge related to materials engineering.	Engineering and Technology	Students' knowledge, problem solving skills and communication were significantly improved in the flipped classroom session.
77	Mitchell (2017)	Explored the use of flipped classroom in promoting students' understanding of theoretical and practical aspects.	Engineering and Technology	The flipped classroom model helped students to easily understand the relation between the theoretical and practical aspects of the subject.
78	Mutch et al. (2017)	Studied the impact of flipped classroom in fostering deeper learning through collaborative process.	Medical and Health Sciences	The flipped classroom model improved students' engagement and performance in collaborative learning activities.

79	Cabı (2018)	Investigated the impact of flipped classroom verses traditional classroom on students' academic achievement.	Social Sciences and Humanities	Students' learning in the traditional classroom and the flipped classroom was the same.
80	Lee and Wallace (2018)	Investigated the impact of flipped classroom in foreign language classroom verses traditional approach on students' achievement.	Social Sciences and Humanities	Students in the flipped classroom course achieved higher average scores than those in the non- flipped classroom course.
81	Ritzhaupt and Sommer (2018)	Compared the impact of the flipped classroom model and traditional classroom on learners' achievement and satisfaction.	Education	Students' satisfaction was increased when using the flipped classroom approach.
82	Xiu, Moore, Thompson, and French (2018)	Explored students' attitudes towards the use of flipped classroom in learning science.	Education	Students' attitude toward the use of flipped classroom was positive.
83	Chien and Hsieh (2018)	Investigated students' learning achievement, motivation, and receptivity towards the use of flipped classroom versus traditional classroom.	Engineering and Technology	Students' learning achievement and motivation were improved.
84	Ng (2018a)	Explored the effectiveness of using flipped classroom to learn photo editing techniques.	Art	No significant differences between students' final scores were found when learning with and without flipped classroom.
85	Chen, Chao, and Hung (2018)	Explored students' perceptions of learning English as a foreign language in the flipped classroom.	Social Sciences and Humanities	Students' attainment value, intrinsic value, utility value, and satisfaction were improved with the use of flipped classroom.

3.1.1 Flipped Classroom in Engineering and Technology

The implementation of flipped classroom in teaching engineering and technology-related subjects has encouraged instructors to create a challenging environment that helps learners link new knowledge to old by engaging them in effective discussions and exercises. Our review of previous studies in this domain showed that students' reaction to the flipped classroom was generally positive. Many students thought that learning in the flipped classroom environment would facilitate their understanding of the subject material and assigned projects (Zappe et al., 2009). This is because they considered flipped classroom as an effective approach to stimulate their interaction with the instructor throughout the learning phases (Velegol et al., 2015).

Other previous studies (e.g., Amresh et al., 2013; Velegol et al., 2015) found that students' performance score and computing self-efficacy were improved even when students found the flipped classroom to be overwhelming and intimidating at times. This can somehow be associated with students' positive perception of the flipped classroom format in which it allowed them to cover more material and, thus, perform better in quizzes and exam (Chien & Hsieh, 2018; Mason et al., 2013; Toto & Nguyen, 2009). As such, it can be anticipated that the structure of the instructional materials for teaching engineering courses would benefit from the flipped classroom format as it enables students to take a very active approach in carrying out the group activities, debating with each other and researching online resources to solve the problems and justify answers.

Flipped classroom can also be used to develop students' problem solving skills, motivation, and engagement as well as ownership of learning engineering subjects (McCredden et al., 2017; Panuwatwanich, 2017). This led the majority of students in previous studies to perceive it as a valuable addition to the traditional method, especially for gaining accurate understanding and judgement of the concepts being taught (Mitchell, 2017). However, no significant impacts of flipped learning on students' learning in this domain were also addressed. For example, Hotle and Garrow (2015) found no significant difference in students' performance when learning in the flipped and traditional classrooms. They stated that none of the flipped classroom and traditional classrooms promoted or inhibited good study habits among engineering students, where successful students are likely to continue being successful with regards to the medium of instruction. Pardo and Mirriahi (2017) explained the negative impact of flipped classroom on students learning, arguing that this method may not traverse the revised Bloom's taxonomy (such as synthesis that are of interest, retention and integration of knowledge or mastery of difficult concepts to increase student engagement and active learning in the classroom) appropriately, so that to start from acquiring basic knowledge about a concept and then making a transition to the point for creating artefacts within that area. This study is of the view that the adaptation period to the format and structure of this model may influence the ability of students to make sense of the new knowledge.

Based on these observations, it can be said that the utilization of flipped classroom in the engineering and technology discipline can promote students' participation in active exchange of ideas and information, which may potentially increase their interest and promote critical thinking and understanding of the learning materials. In addition, students' achievement, self-efficacy and interaction can also be increased when the flipped model is used. For example, providing learning notes before class may allow students to set short-term and long-term goals essential for solving assignments, which can be further enforced by receiving instructor feedback on their progress in in-class discussion. Finally, students' ability to solve complex problems can be also enhanced with this method by providing the motivational bases for independent information search, thus guiding them to become aware of the possible solutions to these problems.

3.1.2 Flipped Classroom in Mathematics

The implementation of the flipped classroom approach for teaching mathematics subjects was mostly devoted to the learning of statistics and calculus. Peterson (2016) found that using flipped classroom to develop positive impression among students could result in higher satisfaction and achievement as compared to the traditional lecture. This is because understanding complex statistical concepts via video instruction can help students address new gaps in knowledge, or reinforce their learning experience. As students' knowledge of statistics grew, they would often glean additional insight from the videos. Tawfik and Lilly (2015) stated that flipped classroom significantly affect students' self-efficacy, self-directed learning, and understanding of statistical techniques and methods. McCallum et al. (2015), on the other hand, emphasized that students' involvement in the learning activity can be facilitated by this model through the facilitation of note taking, video viewing, and collaboration.

The main concern observed from using flipped classroom in this domain was that it can provide an alternative source of teaching complex matters that traditional class cannot convey or enforce. Despite these positive experiences, Davies et al. (2013) found no significant differences in students' achievement when using the flipped classroom approach and the traditional classroom, where students in the flipped classroom environment were found to be less satisfied with how the classroom structure oriented them to the learning of statistics (Strayer, 2012). Probably, the no significant effect of flipped classroom on students' learning can be attributed to the lack in developing the video resources to comply with the complexity of the learning task taught in the class (Reyna, Davila, & Meier, 2016).

Based on these, this study anticipated that students' engagement and behavioral attitudes can be enriched with the use of flipped classroom through collaborative learning and sharing of ideas among the members of the course. It is also important to note that engaging students in in-class collaborative exercises can be beneficial for acquiring conceptual knowledge needed for the students to develop their critical thinking skills and learning performance. Moreover, flipped classroom can offer the medium (in-class activities) for students to be involved in making their own rules before the class start, which would facilitate their self-directed learning by continuously monitoring own learning progress (receive feedback and communicate with others) before and during the class sessions.

3.1.3 Flipped Classroom in Medical and Health Sciences

The review of previous studies (e.g., Hanson, 2016; Porcaro et al., 2016) revealed an exceptional role of the flipped classroom in teaching medical and health sciences subjects. Interestingly, the utilization of flipped classroom was mostly found in areas related to the teaching of pharmacy and healthcare professional subjects (23.5%). This can be reasoned to that medical, nursing, and pharmacy schools all have been challenged to better prepare their students to meet the evolving health care needs of society (Pierce & Fox, 2012). The majority of these studies reported significant effects of flipped classroom on students' learning. For example, the flipped classroom model was extensively used to aid learners' understanding of complex health concepts (Gilboy et al., 2015).

In pharmacy education, McLaughlin et al. (2014) asserted that flipped classroom can be used to facilitate aspects related to learning, guiding students to the content, organizing interactive experiences, challenging students to think creatively, and providing expert insight and feedback. Furthermore, nursing education was another key area that benefited from using flipped classroom as it allowed nursing students to establish small group discussion in case studies, simulation, and other learning activities related to clinical practice. This is evident from the work of Missildine et al. (2013) who examined differences among three educational

delivery methods (traditional lecture only, lecture capture as an adjunct to traditional lecture, and flipped classroom) on students' mean examination scores. They found that the use of the flipped classroom method offered a higher course examination average for students than other methods. While the format of courses in this domain varies significantly (e.g., courses designed where the traditional gender role is female) (Stott, 2004), a wide array of active-learning strategies has been shown to improve learning by dispelling traditional nurse role stereotypes when the goal of retaining male nursing students is to be realized. This could explain why McLaughlin et al. (2013) found the flipped classroom to be an effective approach for improving students' examination scores and satisfaction. Also, Schwartz (2014) found the flipped classroom to be a highly effective method for engaging nursing students with the activities.

Yet, results of some students were inconsistent to what previously stated about the flipped classroom effectiveness in this domain. For example, Moffett and Mill (2014) noted that students in the traditional classroom have outperformed the flipped classroom students. The authors reasoned that students could be reluctant to do the extra work required if they do not see the benefit of doing it. Whillier and Lystad (2015) reported no significant differences in students' final grades and self-rated knowledge in the flipped and traditional classrooms. This led us to assume that flipping the classroom still requires flipping students' perceptions in order for them to accept the responsibility for teaching themselves and spending their own time online to cover much of the materials. This was supported by other previous studies (e.g., Harrington et al., 2015; Liebert et al., 2016; Simpson & Richards, 2015) that showed no difference between mean scores in two treatment groups (flipped classroom versus traditional lecture). It is also important to say that the focus of the flipped curriculum in medical education is limited to the learning of simulation-based skills, where students' performance and perception alone may not be fully representative of student learning in such context (Wong et al., 2014).

In summary, one can conclude that when students are provided with the video materials to supplement in-class discussion, an increase in their mental effort is expected, thereby maintaining performance at a constant level (but, at the cost of an increase in cognitive load). This would probably help students gain a better understanding of the topic and motivate them to express their own thoughts during the collaborative learning process. It is also likely that students' satisfaction with the course will be enhanced as they become more familiar and confident to take an active role in class discussion. Meanwhile, self-direction can be encouraged when using flipped learning, particularly by assigning pre-recorded video lectures to students for homework in addition to selected reading assignments, thus facilitating performance during collaboration.

3.1.4 Flipped Classroom in Natural Sciences

The flipped classroom has also been widely used for teaching natural sciences subjects (Esson, 2016). The review of the literature revealed that chemistry was the main area that benefited from utilizing such a method. The flipped approach was found to facilitate students' engagement and self-efficacy in learning by encouraging them to think about the topic and work with peers to solve problems (Soult, 2016). These activities were believed to have enabled students to achieve high grades as compared to outcomes from the traditional lecturing method (Yestrebsky, 2015, 2016).

In the biology course, Van Vliet et al. (2015) found that using the flipped classroom enhanced students' metacognition and collaborative-learning strategies in the class, mainly because it helped them discuss concepts with one another ("buzz groups") and engaged them in deeper learning. Another study by Mzoughi (2015) applied the flipped approach in

learning physics in which he indicated that students, generally, valued the interaction with the instructors and other peers.

Despite these views, some conflicting results about its effectiveness in teaching chemistry subjects were noted. For example, Ryan and Reid (2015) and Ojennus (2016) found no difference in exam performance between the flipped and control groups. Jensen, Kummer, and Godoy (2015) also found no significant differences in learning gains and attitudes among students who used the flipped and traditional classrooms. There may be a number of factors associated with such outcomes, such as cross-talking between students, which may significantly affect the sharing of resources and understanding of the content in the flipped classroom environment (see next section).

Our review of the literature on the use of flipped classroom in natural sciences lead us to conclude that experiences associated with students' self-learning prior to the class and collaboration during the class session can ultimately increase performance and self-efficacy among students. This include learner-to-learner interaction, and possibly even student metacognitive development, by leveraging student reflections on learning-based experience and understanding of complex concepts. For example, when students are shown how to solve problems they will encounter using video examples, their knowledge application, interaction, and independent learning skills are likely to be relevant to the classroom discussion. This, as a result, can increase students' satisfaction by developing their interest to demonstrate what they know and disguise what they do not know so they can act on their learning during the class period.

3.1.5 Flipped Classroom in Social Sciences and Humanities

The literature in the social sciences and humanities has shown how the flipped approach was used to increase the interaction between students or between student and instructor. The use of flipped classroom was mostly devoted to the teaching of language courses where it has contributed positively to students' learning outcomes and attitudes/perceptions toward the learning experience (Chen et al., 2018; Evseeva & Solozhenko, 2015; Hung, 2015; Phillips & Trainor, 2014). It is also important to say that this method played a key role in increasing students' level of motivation by making them more active in using idioms in class (Chen Hsieh et al., 2017), perception (Roach, 2014), involvement in learning, understanding of the material, and confidence (Kurtz et al., 2014; Prashar, 2015). This is probably because the flipped learning approach may have transformed the way students communicate with the tutor, which, as a result, has greatly stimulated their sense of engagement and performance (Wright et al., 2017). In addition, Lee and Wallace (2018) found that students in the flipped course achieved higher average scores than those in the non-flipped course.

However, Wanner and Palmer (2015) found that not all students in the flipped classroom environment were 'flexible students' and not every student was ready for, and open to, more personalized and self-regulated learning. The time commitment for students to learn and discuss shared outcomes among students was not supported by the flipped classroom model. This is supported by Brooks (2014) who found that teaching information literacy with the flipped approach had no effect on students' learning and perceptions towards the course.

So, in conclusion, it is reasonable to say that the utilization of flipped classroom in social sciences and humanities disciplines can foster students' engagement through affective interaction with the video and other supplementary learning materials before the class session. These are believed to provide the necessary clarification for students to retain the information they are learning which may help them to effectively revise their work based on the feedback they get from instructors in face-to-face classes discussion. The flipped classroom can also increase students' involvement in the collaborative task. It is assumed that when students are able to individually solve problems before the class, they will be more

oriented toward task-mastery goals which may contribute to their ability to solve complex problems when they progress in their studies. Meanwhile, students may develop positive perceptions about the learning process for the mastery of the topic. These perceptions can increase students' motivation to communicate with their instructors during the class period, thus allowing them to deeply understand the learning materials given prior to the class.

3.1.6 Flipped Classroom in Education

In the teaching of education courses, most previous studies found the flipped model to enable students to process higher level of reflection and inquiry (Vaughan, 2014). The flipped classroom can also promote students' creativity through fluency, flexibility and novelty (Al-Zahrani, 2015). This is because the nature of the challenge in this model would stimulate the development of learners' self-efficacy and knowledge (Hao and Lee (2016), and promote their positive perceptions towards the course (Zainuddin & Attaran, 2016). Xiu, Moore, Thompson, and French (2018) stated that using the flipped classroom can enable students to develop positive attitudes toward the learning process. Ritzhaupt and Sommer (2018) found that using the flipped classroom can potentially increase students' satisfaction with the learning process, but not their achievement. Similarly, Fraga and Harmon (2014) found no significant differences in students' achievement when using the flipped and traditional teaching approaches.

In conclusion, learners' participation in collaborative sessions during class can promote positive interdependence while at the same time maintaining a certain level of competition essential for keeping students' interest in in-class discussion. When students are exposed to learning problems using supportive materials that are consistent with their learning styles, they are likely to develop positive attitudes towards the way of instruction they have experienced. This also often involves enacting behaviors that can lead to satisfaction, and attainable learning outcomes.

3.1.7 Flipped Classroom in Arts

The implementation of the flipped classroom for teaching Arts courses was limited to captioning and simplifying the process for creating text during the audio portion of a video (Enfield, 2013). The flipped classroom was also found to offer a feasible solution for students to connect new and previous knowledge in a cooperative learning experience (Danker, 2015). In 2018, Ng (2018a) reported no significant differences between students' final scores when learning with the traditional and flipped lectures. Still, the use of flipped classroom in the Arts disciplines can serve as an effective medium for students to actively participate in design-related problems especially when ideas and thoughts can be conveyed during the in-class discussion.

After all, we extracted information about the impact of the flipped environment in promoting learners' learning. In our compilation of the learning factors across the seven disciplines, we only included those that were mentioned in more than one of the previous studies. As presented in Table 2, a total of 14 learning outcomes were identified (engagement/participation, perceptions and attitude, metacognition, performance, understanding, self-efficacy, satisfaction, problem solving, motivation, involvement, time commitment, interaction, and self-directed learning). To quantify the effect of using the flipped classroom approach on students' learning, the effect size (Cohen's *d*) based on the means and standard deviation reported in each study was computed. In order to obtain the net mean and standard deviation for each learning outcome, we added together all the means and standard deviations of each factor and divided the figures obtained by the total number of studies. Then, further analyzes was conducted based on the sample sizes and averaged effect

sizes. Meta-analyses were conducted using a fixed effects model. Chi-square statistic (Q) and the I^2 measure were used to explore the homogeneity of the selected studies.

In the 85 studies that reported the potential influence of flipped classroom on students' learning across disciplines, only observational studies were used to calculate the effect size for the learning outcomes listed in Table 2.

The results showed an effect size difference of $d = 0.9$ (95 %, CI 0.7 to 1.1, $p < 0.03$). This finding suggests that the identified learning outcomes had positively affect students' learning across disciplines. The Chi-square test for heterogeneity was non-significant ($p = 0.13$), and the I^2 measure of heterogeneity was 41.2%.

Table 2

The impact of using flipped classroom in promoting students' learning across disciplines

									Statistics		Meta-analysis results			
		Engineering & Technology	Mathematics	Medical & Health Sciences	Natural Sciences	Social Sciences & Humanities	Education	Arts	N	Net Mean	Net SD	Z	Lower CI	Upper CI	*p*
1.	Engagement/participation	+	+	±	+	+	+	+	1320	4.23	1.04	3.44	2.26	4.63	0.022
2.	Perceptions and attitude	±	±	±	−	+	+		736	3.72	0.84	4.33	2.11	5.21	0.013
3.	Metacognition [critical thinking; retention & mental effort]	+	+	+	±	+	+		942	4.67	1.22	3.38	1.89	4.87	0.030
4.	Performance	±	+	±	±	±			693	3.16	0.45	3.39	2.78	4.01	0.032
5.	Understanding	+		+	+	+	−		466	5.87	1.07	4.68	3.42	5.94	0.010
6.	Achievement	+	±		+	±	±	±	531	4.26	0.67	3.98	2.86	5.11	0.002
7.	Self-efficacy	+	+		+			−	356	5.48	1.43	4.35	3.07	5.64	0.020
8.	Satisfaction		−	+	+		+		301	4.12	0.77	3.69	2.89	4.50	0.013
9.	Problem solving	+			+	+			354	4.98	0.89	5.18	5.15	5.21	0.000
10.	Motivation	+				+			163	5.10	1.26	5.23	5.13	5.32	0.005
11.	Involvement		+			+			394	5.62	1.60	5.62	5.56	5.67	0.003
12.	Time commitment					−			223	4.32	0.83	3.02	2.17	3.86	0.052
13.	Interaction	+			+				113	3.96	0.53	3.55	3.11	3.98	0.042
14.	Self-directed		+	+					142	4.00	1.04	4.45	4.25	4.65	0.000

+: significant effect

−: no significant effect

SD: Standard deviation; N: sample size; Z: effect size; CI: Confidence intervals; p: level of statistical significance for the aggregated effect size

From the table above, it can be seen that promoting student' engagement and participation in the learning process was the main learning focus of previous studies on flipped classroom across the seven disciplines. This can be due to the role of flipped classroom in facilitating reasoning on learning resource usage as well as allowing students to participate in active-learning exercises during face to face class time. In addition, the flipped learning approach can positively influence students' attitudes and perceptions towards the learning process mainly through skill improvement. Metacognition skills such as critical thinking and retention were also influenced by the flipped learning model across all disciplines, except for Arts major students, which can be due to its role in promoting student empowerment and student-centered course design. The results also showed that performance of students can be effectively improved by engaging them in the flipped learning activities. This can be reasoned to the effectiveness of flipped classroom in increasing effort or motivation among students when attempting to solve certain learning problems. The application of flipped learning in promoting students' understanding and achievement was commonly found in disciplines such as engineering and technology, social sciences and humanities, and natural sciences. It is possible that students in these disciplines may be more computer literate than others which enables them to progress more easily, thus achieving better learning performance. And the same thing can be said with regard to the influence of flipped learning on students' self-efficacy in the disciplines of engineering and technology, mathematics, and natural science. The potential of using flipped classroom for increasing students' satisfaction about the course was also addressed by few previous studies in disciplines such as education, social sciences and humanities. It is believed that the use of the flipped classroom approach could increase levels of participation among students and control over their learning. As for promoting students' problem-solving skills, the results showed a promising impact of the flipped learning approach in science-based disciplines where constructing knowledge may rely less on personal opinions than on weighing up evidence from multiple sources (Brownlee, 2004).

However, the use of flipped classroom for the promotion of students' problem solving, motivation, involvement, time commitment, interaction, and self-directed were the least studies topics across all disciplines. For example, a literature survey showed no studies on the application of flipped classroom in disciplines such as education, arts, medical and health sciences, social sciences and humanities. The reason for the limited studies on flipped learning in these disciplines can be largely due to the nature and the practical use of the flipped learning model itself, which tends to be more successful when the instructor provides multiple methods for students (Lento, 2016). Therefore, future studies can and must change in these directions in order to provide a wider range of perspectives that facilitate students' development in these areas.

4. Opportunities and Challenges of Flipped Classroom

The use of flipped classroom in higher education would offer some opportunities (see Table 3) for students to master and manage their learning. This include the development of students' deep understanding of the materials by enabling them to re-watch and skip the parts they have mastered (Zainuddin & Attaran, 2016).

1) In medical and healthcare, the flipped learning can be used to offer application of theoretical information to foster the clinical and other health professional practices, which might create a forum to develop shared expectations among students and faculty. It is evident from the literature that this approach may facilitate students' attention on certain problems or discussions by engaging them in enriched conditions and formats (McLaughlin et al., 2014). Experiences emerged from using the flipped learning approach were claimed to have profound consequences on students' mastery of the topic as it

enables them to add to the existing knowledge and make inferences based on those knowledge resources (Harrington et al., 2015).

2) In engineering and technology, the flipped classroom may offer opportunities to save the time required for instructors to teaching and convey the new information to the students. It is generally perceived as a practical way for instructors to provide instant reflection and feedback to the students.
3) In mathematics, the flipped classroom can provide opportunities for students to transfer their knowledge between contexts along with the acquisition of information, ideas, and reflects in a task-specific sense (Strayer, 2012). In addition, it can enable students to ask relevant questions and receive answers from other members.
4) In social sciences and humanities, the flipped classroom can offer a meaningful solution for teachers to provide multiple visual inputs essential for students to acquire deeper learning (Phillips & Trainor, 2014). It can enable students to invest their time in independent self-study away from the classroom. Thus, the learning outcomes from such practices may significantly shape students' positive perception about the effectiveness of flipped classroom to learn the content with minimal confusion.
5) In natural sciences, the flipped classroom can offer exceptional opportunities for students to underpin the practical procedures before the laboratory session starts, as well as provide more timely and accurate preparation for deep learning (Van Vliet et al., 2015). It can reduce the cognitive load of the learner by creating individualized differentiated learning environments (Esson (2016).
6) In education, the flipped classroom may potentially facilitate students work process in a collaborative setting that, typically, requires appropriate "soft skills" and use of sufficient instructional resources in the classroom environment (Hao & Lee, 2016). This can be achieved by helping students expand and elaborate during the discussion process, which might contribute to developing shared understandings (Vaughan, 2014).
7) In Arts (e.g., multimedia and filming), the flipped classroom can help in decreasing the amount of preparation time and delivering the content to large classrooms (Conner, Stripling, Blythe, Roberts, & Stedman, 2014; Danker, 2015).

Despite the various opportunities associated with the use of flipped classroom, the implementation this model in the domains mentioned above, unfortunately, comes with some challenges (see Table 3). The main challenge of this method, shared across all disciplines, was mostly devoted to the length of the video and time required for students to master the learning material (Koo et al., 2016; Velegol et al., 2015; Whillier & Lystad, 2015). Meanwhile, the lack of immediate feedback —provided to students— and course structure were found to negatively influence the implementation of the flipped classroom in a university context (Hotle & Garrow, 2015; Peterson, 2016).

1) In engineering and technology, students' interactions with the video and other peers can be easily affected by the lack of practical sessions important for enriching their understanding of the activity in the flipped classroom environment (Blair et al., 2016), which might also increase the frustration of weaker students. The pedagogical challenge of using this method in teaching math was related to the lack of focused activities, so that students can successfully accomplish their learning in practice. Other standardization-related issues between the learning phases were also addressed to impose additional demands on students to adapt to a new structure that they are not familiar with (Peterson, 2016).
2) In the mathematics domain, challenges of flipped classroom were mostly related to limiting students to express about their views while watching the videos. Also, students in the flipped learning session may not truly engage in self- discipline.
3) In medical and health sciences, aspects related to the needs for sufficient technical support to facilitate delivery of pre-recorded lectures and requirements for in-person faculty

contact were repeatedly highlighted when using this method. In addition, the difficulty to meet all accreditation criteria when restructuring the flipped instructions was claimed to be the key obstacle for using it in this domain (Wong et al., 2014).

4) Although the flipped classroom has gained popular attention in the teaching of social sciences and humanities subjects, several challenges can be still identified. For example, this method may not necessarily provide the temporal flexibility when the homogeneity and integrity of contents are in question. This is possibly due to the structure of the social science disciplines which is designed to favor theoretical knowledge over practical knowledge. The observation of the literature lead us to assume that the learning experience in the flipped classroom environment may not encourage students to further expand into new and more challenging territories (Wanner & Palmer, 2015), so they acquire the skills to engage in deeper learning experiences.
5) As for the challenges emerged from using the flipped classroom in teaching natural sciences subjects, poor note-taking and presence of the instructor were the main factors that could influence students' learning and perceptions of the environment (Jensen et al., 2015; Ryan & Reid, 2015).
6) In the education domain, issues related to the requirement for discipline-specific skills and pre-preparation to implement the flipped learning model were mostly noted in the literature (Al-Zahrani, 2015). Other issues related to sound quality and the placement of lectures were also addressed, which claimed to distract students during the discussion session (Fraga & Harmon, 2014).
7) Furthermore, the main challenge of using flipped classroom in teaching Arts subjects was found to be associated with students becoming bored with the repetitive exercises and instructions in the video (Enfield, 2013).

Based on these opportunities and challenges, this study anticipated that implementing the flipped learning approach would result in different consequences, thus influencing the overall learning experiences of the students.

Table 3
Opportunities and challenges of flipped classroom across disciplines

Domain		Opportunities	Challenges
Engineering and Technology	Environmental; Industrial; Software; Civil & Architecture	• Saves instructors' time. • Helps convey new materials and examples. • Allows students to pause and re-watch the lectures. • Gives an instant reflection and feedback on the students' understanding of the concepts. • Offers formative learning that could be demonstrated in the later deliverables.	• Easy to get distracted while listening to the video lecture. • Long videotaping sessions. • Course structure issues. • Requires more time from students to master the content. • Lacks immediate feedback. • Increase the frustration of weaker students. • Requires balancing the "technical" contents. • Lacks practical sessions or laboratory work.
Mathematics	Statistics & Calculus	• Enables students to transfer their knowledge between contexts and thus strengthen conceptual understanding. • Helps in the acquisition of information, ideas, and reflects upon these experiences. • Provides a scalable way to deliver content to large classrooms. • Allows to skip the familiar parts of the lesson and re-play the challenging one. • Allows to ask questions.	• Not focused enough for students to successfully accomplish their learning in practice. • Does not allow students to ask questions while watching the videos. • Self-discipline. • Requires significant time and resources investment. • There is no standardized comparison between sections.

Medical and Health Sciences	Medicine; Pharmacy; Nursing & Healthcare professionals (Physical therapist; nutrition; and veterinary medicine)	• Enables students to apply knowledge to clinical case scenarios in class. • Keeps students' attention focused on problems or discussions. • Enables application of theoretical information to clinical practice. • Offers different curricular formats. • Provides a forum to develop shared expectations. • Helps students determine what topics they have mastered and which topics still present gaps in understanding. • Supports cognitive constructivist theory by demonstrating mastery of content.	• Requires sufficient technical support to facilitate delivery of pre-recorded lectures to students. • Requires additional time to synthesize information. • Requires in-person faculty contact. • Limited access to high-speed Internet. • Length of the video and class sessions. • Difficult to meet all accreditation criteria when restructuring the curricula.
Social Sciences & Humanities	Business; Management; Accounting; Language & Literacy	• Provides a variety of visual inputs. • Facilitates deeper learning in a short time period. • Forces students to invest time in independent self-study away from class. • Offers a means to address student involvement and, in turn, student learning. • Allows to preview and review. • Gives the opportunity to use vocabulary and idioms.	• Less time is devoted to the class lecture. • Lacks temporal and locational flexibility. • Self-discipline. • Unstructured classroom activities and unpredictable homework. • Lacks homogeneity and integrity of contents. • Students may find it difficult to engage in large group discussions. • Requires intrinsic drivers to stimulate reflection.
Natural Sciences	Physics; Chemistry; Biology	• Helps underpinning the practical procedures before the laboratory lesson. • Decreases the likelihood of cheating. • Provides more timely and accurate preparation. • Helps develop learning strategies for deep learning. • Allows students to listen to the lecture more than once. • Helps students to deal with complex ideas. • Facilitates the development of sophisticated epistemology. • Reduces the cognitive load of the learner.	• Poor note-taking and length of the video. • Difficulties to convey the same information using slides and voice. • Presence of the instructor in the flipped classroom environment.
Education	Instructional; Teachers Education & Education Development	• Allows students to repeat the video several times. • Allows students to work in teams that require appropriate "soft skills". • Allows students to be independent and autonomous. • Helps to expand or recreate the experiences to match students' knowledge.	• Sound quality issues and the placement of lectures. • Students must have discipline-specific skills and knowledge • Time management and confusion issues.
Arts	Multimedia & Filming	• Decreases the amount of preparation time. • Information in the videos is repetitive.	• Technical difficulties. • Repetitive instructions.

5. Extensions to the Flipped Classroom Model

Many studies have extended the design of this method as an attempt to overcome the abovementioned challenges. For example, Chen and Chen (2014) and Wang and Liu (2018) proposed revising the current flipped classroom model to offer a better solution to the current pedagogical discourse by covering aspects related to flexible attributes, learner-centered approach, intentional content, professional educators, progressive networking activities, engaging and effective experiences, and diversified and seamless platforms. However, students in this model are still facing adoption related difficulties because of their residual passive learning ways which emerged from the traditional classroom, where learning required less proactive effort.

Jinlei and Baohui (2013), on the other hand, extended the current formation of the flipped classroom model using game-based learning in order to create an effective and relaxing environment. The use of games with the flipped classroom approach was claimed to foster students' initiatives, creativity and teamwork skills, something that the conventional model cannot exploit alone. This practice has been later extended by Latulipe, Long, and Seminario (2015) who proposed structuring the flipped classroom format with lightweight teams and gamification for the purpose of increasing students' engagement in the discussion by supporting their problem solving practices. It was argued that using lightweight teams will promote students' social needs without the stress within a high-stakes team. Despite the effectiveness of the flipped classroom, inexperienced students may still find it frustrating when they cannot work with others.

Another attempt was carried out by Jonsson (2015) and Chen, Lang, Lu, and Shi (2018) to empower the flipped lectures combined with certain elements of peer discussion and just-in-time teaching. Results showed that using this extension would significantly increase students' learning of engineering and technology courses. Another effort to enforce the active learning practices among students in the flipped learning environment was performed by Li, Lou, Tseng, and Huang (2013) using Facebook-based learning platform. It was claimed that using this extension will significantly contribute to learners' participation and interaction in blended learning activities.

In teaching medical and health related topics, Talley and Scherer (2013) and Ng (2018b) combined the flipped learning activities with other learning techniques such as self-explanation and practice testing in order to increase students' achievement. The process involved the use of self-explanation technique to help students to interpret the process in their own words, which claimed to increase their time to study and understand the course materials. Galway, Corbett, Takaro, Tairyan, and Frank (2014) proposed an integration of the online NextGenU portal and the flipped learning approach in public health higher education. They stated that using such combination helps to stimulate students' positive learning experience and attitudes towards environmental and occupation health.

Based on these extensions, this study is of the view that the flipped classroom model has proven to be remarkably effective in teaching engineering and medical subjects. Insights from these extensions can be linked with production of learning strategies to deepen students' knowledge gained from the post phase, which, as a result, could stimulate their engagement and understanding of the materials. Yet, further works are still needed in order to ensure efficient execution of flipped learning in a domain-specific context.

6. Final Remarks

This study was concerned about mapping the effectiveness of the flipped classroom approach in various domains to help students achieve certain learning outcomes. For example, this study found that applying the flipped classroom in mathematics can help students to engage in deeper learning and understand the taught concept through the stimulation of their awareness of the critical inquiry process. The flipped classroom can also provide a promising solution to the learning of theoretical knowledge as it builds the necessary experience for students to be involved in the learning process within a shorter period of time. This led us to think that the flipped classroom model is a good fit for teaching social sciences-related courses. It can be due to the nature of these courses, which related to linguistic and logical intelligence that benefit from the re-watching of lecture videos to master the task at hand. Learning of these courses is less likely to require previous educational or work experiences as compared to engineering and science subjects (Head, 2008).

Yet, it is important to mention that flipped learning is not necessarily advantageous for promoting positive perceptions and attitude among learners. This assumption, of course, varies from one context to another based on the strategies used to design the instructional videos. The time spent, and technical difficulties were found to be the main obstacles faced by students and instructors when using or designing the flipped classroom model. Other design complexity and limited practical sessions were also reported to have a negative influence on students' and instructors' perception about the flipped classroom effectiveness, particularly in engineering and medical domains. The implementation of flipped classroom in higher education is used to promote students' engagement, perceptions and attitude, different forms of metacognition, performance, understanding, achievement, and self-efficacy, respectively. The role of facilitator to help ensure timely discussion between learners in the group has contributed to these outcomes. In addition when learners spend less time in mastering the task, they will be able to give more time to other functions that would contribute to the development of their learning outcomes (Davies et al., 2013).

Many issues are still debated, but from what we have reviewed, extending the flipped classroom model to cover relevant concepts in a particular domain is needed. This is simply because applying the conventional form of the flipped classroom in certain domains may not really pay off (see Table 3). Therefore, when designing the instructional materials, it is advised that instructors and educational policy makers consider the nature of the learning task and efforts needed from student to invest. More works are also needed to reform the structure of the learning sessions to avoid any potential confusion among students when introducing a new concept. More precisely, using the flipped learning approach in teaching science and engineering courses can be further improved with the use of verbal instructions and task-specific scaffolding, for example, the design of instructional videos can benefit from adding extra tutorials and hand-on practices between the sessions, which may help the instructor in conveying the same information taught in the traditional classroom. On the other hand, extending the design of this model can potentially support university students' learning experiences through group discussion, applying active learning strategies, and in-class assignments.

Finally, the development trend of flipped classroom implementation in higher education is illustrated in Figure 4. From the figure, it can be asserted that recognizing the potential of flipped learning in higher education has gradually increased across disciplines. For example, the use of flipped classroom has been mostly to positively influence students' learning in areas such as medical and health sciences, natural sciences, social sciences and humanities. The utilization of the flipped classroom approach in these disciplines is mainly advocated to promote students' engagement, metacognition, attitude, performance, understanding, and achievement, as well as other learning outcomes. It is also reasonable to say that the implementation of this model has provided substantial improvements in students' participation and perception. Our classifications and mapping of flipped classroom use across disciplines will certainly help academicians, practitioners and researchers to understand this new method from a wider perspective.

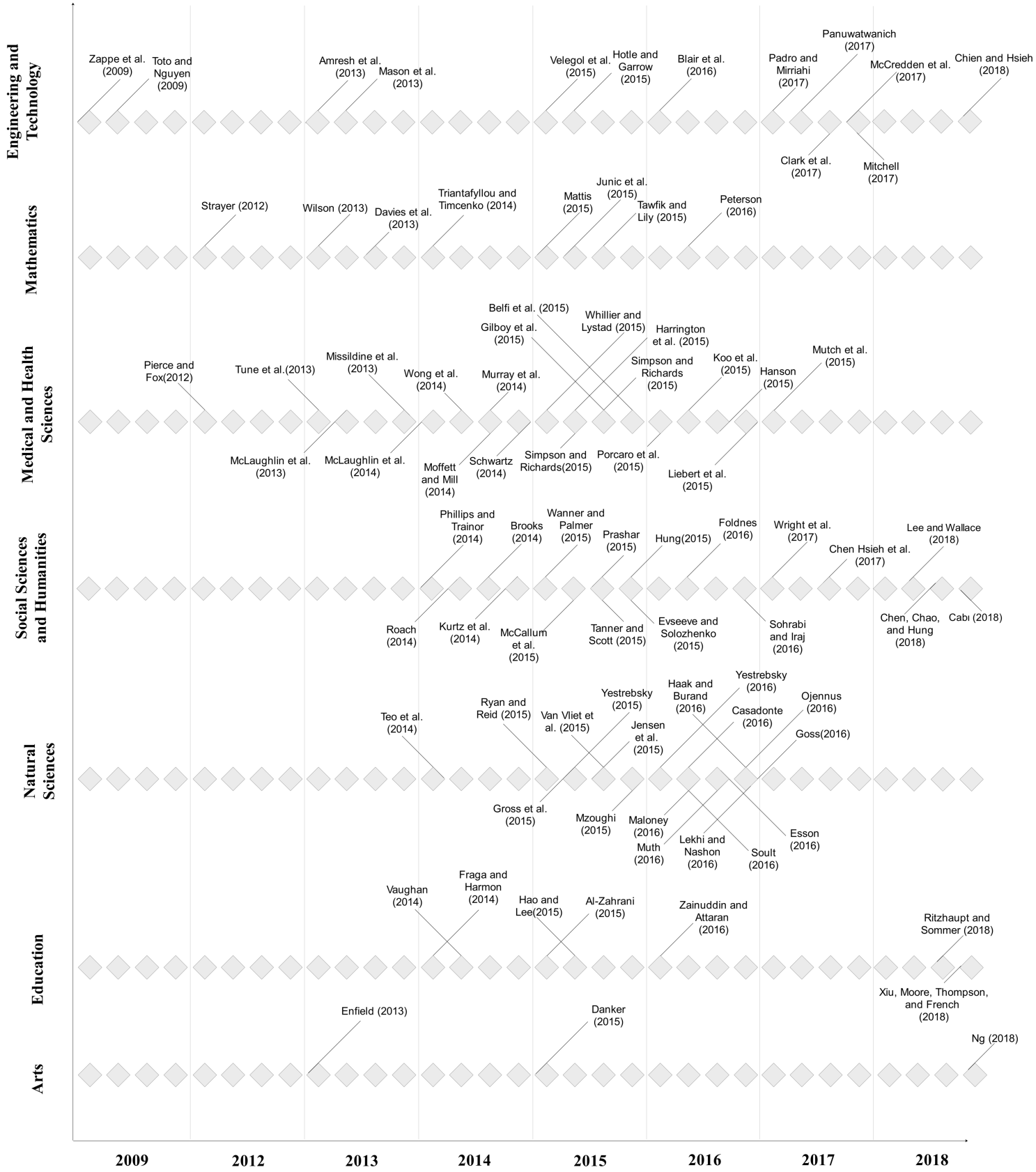

Figure 4: The development trend of flipped classroom use in higher education

7. Conclusion

This study reviewed previous research on the use of flipped classroom in seven disciplines. identify the major opportunities and challenges related to its use, and address extensions of the model. The results showed the potential of using flipped classroom in promoting certain learning outcomes (e.g., engagement, attitude, metacognition, performance, self-efficacy, and understanding) across disciplines. The main opportunity offered by the flipped classroom model was related to the development of students' deep understanding of the materials by providing them with more control over what and how they learn. The flipped classroom was also found to help students to transfer their knowledge between contexts, thus strengthen their conceptual understanding. This also includes facilitating students' acquisition of information, ideas, and reflects upon their self-learning experiences. Despite the opportunities provided by the flipped classroom model, several key challenges were reported. For example, the lack of immediate feedback, course structure, length of the video, and time required for a learner to master the learning material were commonly reported in the literature. However, much fewer challenges were reported in disciplines such as Natural Sciences, Education, and Arts. Students in these disciplines were the least affected by the flipped learning approach, possibly because these disciplines are quite vast. Findings from this study can be used by educational decision makers and instructors to understand how using the flipped learning model can promote certain learning outcomes. In addition, understanding the challenges that students may face in the flipped learning environment can help education decision makers consider the use of effective interventions to eliminate them.

References

Al-Samarraie, H., & Hurmuzan, S. (2018). A review of brainstorming techniques in higher education. *Thinking Skills and Creativity, 27*, 78-91.

Al-Samarraie, H., & Saeed, N. (2018). A systematic review of cloud computing tools for collaborative learning: Opportunities and challenges to the blended-learning environment. *Computers & Education*, *124*, 77-91.

Al-Zahrani, A.M. (2015). From passive to active: The impact of the flipped classroom through social learning platforms on higher education students' creative thinking. *British Journal of Educational Technology, 46*(6), 1133-1148.

Amresh, A., Carberry, A.R., & Femiani, J. (2013). *Evaluating the effectiveness of flipped classrooms for teaching cs1*. Paper presented at the Frontiers in Education Conference, 2013 IEEE.

Andreasen, A.R., Kotler, P., & Parker, D. (2003). *Strategic marketing for nonprofit organizations*: Prentice Hall Upper Saddle River, NJ.

Baragash, R. S., & Al-Samarraie, H. (2018a). An empirical study of the impact of multiple modes of delivery on student learning in a blended course. *The Reference Librarian*, *59*(3), 149-162.

Baragash, R. S., & Al-Samarraie, H. (2018b). Blended learning: Investigating the influence of engagement in multiple learning delivery modes on students' performance. *Telematics and Informatics*, *35*(7), 2082-2098.

Beelmann, A. (2006). *Review of systematic reviews in the social sciences. A practical guide* (Vol. 11): Hogrefe & Huber Publishers.

Belfi, L.M., Bartolotta, R.J., Giambrone, A.E., Davi, C., & Min, R.J. (2015). "Flipping" the introductory clerkship in radiology: Impact on medical student performance and perceptions. *Academic radiology, 22*(6), 794-801.

Betihavas, V., Bridgman, H., Kornhaber, R., & Cross, M. (2016). The evidence for 'flipping out': a systematic review of the flipped classroom in nursing education. *Nurse education today*, *38*, 15-21.

Bishop, J.L., & Verleger, M.A. (2013). *The flipped classroom: A survey of the research.* Paper presented at the ASEE National Conference Proceedings, Atlanta, GA.

Blair, E., Maharaj, C., & Primus, S. (2016). Performance and perception in the flipped classroom. *Education and Information Technologies, 21*(6), 1465-1482.

Brooks, A.W. (2014). Information literacy and the flipped classroom: Examining the impact of a one-shot flipped class on student learning and perceptions. *Communications in Information Literacy, 8*(2), 225-235.

Brownlee, J. (2004). Teacher education students' epistemological beliefs: Developing a relational model of teaching. *Research in Education*, *72*(1), 1-17.

Cabı, E. (2018). The impact of the flipped classroom model on students' academic achievement. *The International Review of Research in Open and Distributed Learning, 19*(3).

Casadonte, D. (2016). The effectiveness of course flipping in general chemistry–does it work? *The flipped classroom volume 2: Results from practice* (pp. 19-37): ACS Publications.

Chen Hsieh, J.S., Wu, W.-C.V., & Marek, M.W. (2017). Using the flipped classroom to enhance efl learning. *Computer Assisted Language Learning, 30*(1-2), 1-21.

Chen, H.Y.-L., & Chen, N.-S. (2014). *Design and evaluation of a flipped course adopting the holistic flipped classroom approach.* Paper presented at the Advanced Learning Technologies (ICALT), 2014 IEEE 14th International Conference On.

Chen, M.-H., Chao, Y.-C.J., & Hung, H.-T. (2018). *Learning in a flipped english classroom from university students' perspectives.* Paper presented at the Proceedings of the 6th International Conference on Information and Education Technology.

Chen, F., Lui, A. M., & Martinelli, S. M. (2017). A systematic review of the effectiveness of flipped classrooms in medical education. *Medical education*, *51*(6), 585-597.

Chen, Y., Lang, F., Lu, Z., & Shi, H. (2018). *Build up peer instruction based flipped classroom with social network.* Paper presented at the International Conference on E-Learning, E-Education, and Online Training.

Chien, C.-F., & Hsieh, L.-H.C. (2018). Exploring university students' achievement, motivation, and receptivity of flipped learning in an engineering mathematics course. *International Journal of Online Pedagogy and Course Design (IJOPCD), 8*(4), 22-37.

Chugani, N., Kumar, V., Garza-Reyes, J.A., Rocha-Lona, L., & Upadhyay, A. (2017). Investigating the green impact of lean, six sigma and lean six sigma: A systematic literature review. *International Journal of Lean Six Sigma, 8*(1), 7-32.

Clark, R.M., Clark, W.W., & Besterfield-Sacre, M. (2017). Experiences with "flipping" an introductory mechanical design course *The flipped classroom* (pp. 131-149): Springer.

Conner, N.W., Stripling, C.T., Blythe, J.M., Roberts, T.G., & Stedman, N.L. (2014). Flipping an agricultural education teaching methods course. *Journal of Agricultural Education, 55*(2), 66-78.

Danker, B. (2015). Using flipped classroom approach to explore deep learning in large classrooms. *IAFOR Journal of Education, 3*(1), 171-186.

Davies, R.S., Dean, D.L., & Ball, N. (2013). Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course. *Educational Technology Research and Development, 61*(4), 563-580.

DeLozier, S.J., & Rhodes, M.G. (2017). Flipped classrooms: A review of key ideas and recommendations for practice. *Educational psychology review, 29*(1), 141-151.

Egger, M., Dickersin, K., & Smith, G.D. (2001). Problems and limitations in conducting systematic reviews. *Systematic reviews in health care: Meta-analysis in context*, 43-68.

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.

Esson, J.M. (2016). Flipping general and analytical chemistry at a primarily undergraduate institution *The flipped classroom volume 2: Results from practice* (pp. 107-125): ACS Publications.

Evseeva, A., & Solozhenko, A. (2015). Use of flipped classroom technology in language learning. *Procedia-Social and Behavioral Sciences, 206*, 205-209.

Foldnes, N. (2016). The flipped classroom and cooperative learning: Evidence from a randomised experiment. *Active Learning in Higher Education, 17*(1), 39-49.

Fraga, L.M., & Harmon, J. (2014). The flipped classroom model of learning in higher education: An investigation of preservice teachers' perspectives and achievement. *Journal of Digital Learning in Teacher Education, 31*(1), 18-27.

Galway, L.P., Corbett, K.K., Takaro, T.K., Tairyan, K., & Frank, E. (2014). A novel integration of online and flipped classroom instructional models in public health higher education. *BMC medical education, 14*(1), 181.

Giannakos, M.N., Krogstie, J., & Sampson, D. (2018). Putting flipped classroom into practice: A comprehensive review of empirical research *Digital technologies: Sustainable innovations for improving teaching and learning* (pp. 27-44): Springer.

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.

Gong, L., Zhang, R., Wu, L., Tian, M., Wu, M., & Zhang, W. (2018). *Application of flipped classroom in college computer experiment course.* Paper presented at the 2018 International Symposium on Educational Technology (ISET).

Goss, L.M. (2016). The use of active learning and a symbolic math program in a flipped physical chemistry course *The flipped classroom volume 1: Background and challenges* (pp. 29-54): ACS Publications.

Graham, C.R., Henrie, C.R., & Gibbons, A.S. (2014). Developing models and theory for blended learning research. *Blended learning: Research perspectives, 2*, 13-33.

Gross, D., Pietri, E.S., Anderson, G., Moyano-Camihort, K., & Graham, M.J. (2015). Increased preclass preparation underlies student outcome improvement in the flipped classroom. *CBE-Life Sciences Education, 14*(4), ar36.

Haak, M.D., & Burand, M.W. (2016). Less class time, more learning: The evolution of a hybrid general chemistry course for science majors *The flipped classroom volume 2: Results from practice* (pp. 39-53): ACS Publications.

Hanson, J. (2016). Surveying the experiences and perceptions of undergraduate nursing students of a flipped classroom approach to increase understanding of drug science and its application to clinical practice. *Nurse education in practice, 16*(1), 79-85.

Hao, Y., & Lee, K.S. (2016). Teaching in flipped classrooms: Exploring pre-service teachers' concerns. *Computers in Human Behavior, 57*, 250-260.

Harrington, S.A., Bosch, M.V., Schoofs, N., Beel-Bates, C., & Anderson, K. (2015). Quantitative outcomes for nursing students in a flipped classroom. *Nursing Education Perspectives, 36*(3), 179-181.

Head, A.J. (2008). Information literacy from the trenches: How do humanities and social science majors conduct academic research? *College & Research Libraries, 69*(5), 427-446.

Hotle, S.L., & Garrow, L.A. (2015). Effects of the traditional and flipped classrooms on undergraduate student opinions and success. *Journal of Professional Issues in Engineering Education and Practice, 142*(1), 05015005.

Hung, H.-T. (2015). Flipping the classroom for english language learners to foster active learning. *Computer Assisted Language Learning, 28*(1), 81-96.

Jensen, J.L., Kummer, T.A., & Godoy, P.D.d.M. (2015). Improvements from a flipped classroom may simply be the fruits of active learning. *CBE-Life Sciences Education, 14*(1), ar5.

Jinlei, Z., & Baohui, Z. (2013). Application of game based learning in flipped classroom [j]. *Journal of Distance Education, 1*, 73-78.

Jonsson, H. (2015). *Using flipped classroom, peer discussion, and just-in-time teaching to increase learning in a programming course.* Paper presented at the Frontiers in Education Conference (FIE), 2015 IEEE.

Jungić, V., Kaur, H., Mulholland, J., & Xin, C. (2015). On flipping the classroom in large first year calculus courses. *International Journal of Mathematical Education in Science and Technology, 46*(4), 508-520.

Karabulut-Ilgu, A., Jaramillo Cherrez, N., & Jahren, C. T. (2018). A systematic review of research on the flipped learning method in engineering education. *British Journal of Educational Technology*, *49*(3), 398-411.

Khan, K.S., Kunz, R., Kleijnen, J., & Antes, G. (2003). Five steps to conducting a systematic review. *Journal of the royal society of medicine, 96*(3), 118-121.

Kitchenham, B. (2004). Procedures for performing systematic reviews. *Keele, UK, Keele University, 33*(2004), 1-26.

Khanova, J., McLaughlin, J. E., Rhoney, D. H., Roth, M. T., & Harris, S. (2015). Student perceptions of a flipped pharmacotherapy course. *American journal of pharmaceutical education*, *79*(9), 140.

Koo, C.L., Demps, E.L., Farris, C., Bowman, J.D., Panahi, L., & Boyle, P. (2016). Impact of flipped classroom design on student performance and perceptions in a pharmacotherapy course. *American journal of pharmaceutical education, 80*(2), 33.

Kurtz, G., Tsimerman, A., & Steiner-Lavi, O. (2014). The flipped-classroom approach: The answer to future learning? *European Journal of Open, Distance and E-Learning, 17*(2), 172-182.

Latulipe, C., Long, N.B., & Seminario, C.E. (2015). *Structuring flipped classes with lightweight teams and gamification.* Paper presented at the Proceedings of the 46th ACM Technical Symposium on Computer Science Education.

Lee, G., & Wallace, A. (2018). Flipped learning in the english as a foreign language classroom: Outcomes and perceptions. *TESOL Quarterly, 52*(1), 62-84.

Lento, C. (2016). Promoting active learning in introductory financial accounting through the flipped classroom design. *Journal of Applied Research in Higher Education*, *8*(1), 72-87.

Lekhi, P., & Nashon, S.M. (2016). How a flipped classroom promotes sophisticated epistemology: Example from a large analytical chemistry course *The flipped classroom volume 1: Background and challenges* (pp. 93-104): ACS Publications.

Li, K.-H., Lou, S.-J., Tseng, K.-H., & Huang, H.-C. (2013). *A preliminary study on the facebook-based learning platform integrated with blended learning model and flip learning for online and classroom learning.* Paper presented at the International Conference on Web-Based Learning.

Liebert, C.A., Lin, D.T., Mazer, L.M., Bereknyei, S., & Lau, J.N. (2016). Effectiveness of the surgery core clerkship flipped classroom: A prospective cohort trial. *The American Journal of Surgery, 211*(2), 451-457. e451.

Maloney, V. (2016). Conversion of a lecture based organic chemistry course sequence to fully flipped classes with pertinent observations from other flipped chemistry courses *The flipped classroom volume 2: Results from practice* (pp. 93-106): ACS Publications.

Mason, G.S., Shuman, T.R., & Cook, K.E. (2013). Comparing the effectiveness of an inverted classroom to a traditional classroom in an upper-division engineering course. *IEEE Transactions on Education, 56*(4), 430-435.

Mattis, K.V. (2015). Flipped classroom versus traditional textbook instruction: Assessing accuracy and mental effort at different levels of mathematical complexity. *Technology, Knowledge and Learning, 20*(2), 231-248.

McCallum, S., Schultz, J., Sellke, K., & Spartz, J. (2015). An examination of the flipped classroom approach on college student academic involvement. *International Journal of Teaching and Learning in Higher Education, 27*(1), 42-55.

McCredden, J., Reidsema, C., & Kavanagh, L. (2017). Designing an active learning environment architecture within a flipped classroom for developing first year student engineers *The flipped classroom* (pp. 97-129): Springer.

McLaughlin, J.E., Griffin, L.M., Esserman, D.A., Davidson, C.A., Glatt, D.M., Roth, M.T., . . . Mumper, R.J. (2013). Pharmacy student engagement, performance, and perception in a flipped satellite classroom. *American journal of pharmaceutical education, 77*(9), 196.

McLaughlin, J.E., Roth, M.T., Glatt, D.M., Gharkholonarehe, N., Davidson, C.A., Griffin, L.M., . . . Mumper, R.J. (2014). The flipped classroom: A course redesign to foster learning and engagement in a health professions school. *Academic Medicine, 89*(2), 236-243.

McLean, S., & Attardi, S.M. (2018). Sage or guide? Student perceptions of the role of the instructor in a flipped classroom. *Active Learning in Higher Education*, 1469787418793725.

Missildine, K., Fountain, R., Summers, L., & Gosselin, K. (2013). Flipping the classroom to improve student performance and satisfaction. *Journal of Nursing Education*.

Mitchell, D. (2017). Flipping the learning of subdivision design for surveying students *The flipped classroom* (pp. 245-256): Springer.

Moffett, J., & Mill, A.C. (2014). Evaluation of the flipped classroom approach in a veterinary professional skills course. *Advances in medical education and practice, 5*, 415.

Murray, L., McCallum, C., & Petrosino, C. (2014). Flipping the classroom experience: A comparison of online learning to traditional lecture. *Journal of Physical Therapy Education, 28*.

Mutch, A., Young, C., Smith, N., van Dooren, K., Ranatunga, C., Gillan, C., . . . Fitzgerald, L. (2017). Flipping a collaborative classroom to gain deeper understanding of the health system *The flipped classroom* (pp. 257-271): Springer.

Muth, G.W. (2016). Biochemistry and the liberal arts: Content and communication in a flipped classroom *The flipped classroom volume 2: Results from practice* (pp. 127-138): ACS Publications.

Mzoughi, T. (2015). An investigation of student web activity in a "flipped" introductory physics class. *Procedia-Social and Behavioral Sciences, 191*, 235-240.

Ng, E.M. (2018a). *Explore the effectiveness of using flipped classroom for university students to learn photo editing techniques.* Paper presented at the EdMedia+ Innovate Learning.

Ng, E.M. (2018b). Integrating self-regulation principles with flipped classroom pedagogy for first year university students. *Computers & Education, 126*, 65-74.

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

Ojennus, D.D. (2016). Assessment of learning gains in a flipped biochemistry classroom. *Biochemistry and Molecular Biology Education, 44*(1), 20-27.

Panuwatwanich, K. (2017). Flipping a postgraduate classroom: Experience from griffith university *The flipped classroom* (pp. 229-243): Springer.

Pardo, A., & Mirriahi, N. (2017). Design, deployment and evaluation of a flipped learning first-year engineering course *The flipped classroom* (pp. 177-191): Springer.

Peterson, D.J. (2016). The flipped classroom improves student achievement and course satisfaction in a statistics course: A quasi-experimental study. *Teaching of Psychology, 43*(1), 10-15.

Phillips, C.R., & Trainor, J.E. (2014). Millennial students and the flipped classroom. *Journal of Business and Educational Leadership, 5*(1), 102.

Pierce, R., & Fox, J. (2012). Vodcasts and active-learning exercises in a "flipped classroom" model of a renal pharmacotherapy module. *American journal of pharmaceutical education, 76*(10), 196.

Porcaro, P.A., Jackson, D.E., McLaughlin, P.M., & O'Malley, C.J. (2016). Curriculum design of a flipped classroom to enhance haematology learning. *Journal of Science Education and Technology, 25*(3), 345-357.

Prashar, A. (2015). Assessing the flipped classroom in operations management: A pilot study. *Journal of Education for Business, 90*(3), 126-138.

Prust, C.J., Kelnhofer, R.W., & Petersen, O.G. (2015). The flipped classroom: It's (still) all about engagement. *ASEE Annual Conference and Exposition, Conference Proceedings, 122nd ASEE*(122nd ASEE Annual Conference and Exposition: Making Value for Society).

Reyna, J., Davila, Y.C., & Meier, P. (2016). *Enhancing the flipped classroom experience with the aid of inclusive design.* Paper presented at the EdMedia: World Conference on Educational Media and Technology.

Ritzhaupt, A., & Sommer, M. (2018). Impact of the flipped classroom on learner achievement and satisfaction in an undergraduate technology literacy course. *Journal of Information Technology Education: Research, 17*(1), 159-182.

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.

Ryan, M.D., & Reid, S.A. (2015). Impact of the flipped classroom on student performance and retention: A parallel controlled study in general chemistry. *Journal of Chemical Education, 93*(1), 13-23.

Schwartz, T.A. (2014). Flipping the statistics classroom in nursing education. *Journal of Nursing Education, 53*(4), 199-206.

Searcy, D.L., & Mentzer, J.T. (2003). A framework for conducting and evaluating research. *Journal of Accounting Literature, 22*, 130.

Simpson, V., & Richards, E. (2015). Flipping the classroom to teach population health: Increasing the relevance. *Nurse Education in Practice, 15*(3), 162-167.

Sohrabi, B., & Iraj, H. (2016). Implementing flipped classroom using digital media: A comparison of two demographically different groups perceptions. *Computers in Human Behavior, 60*, 514-524.

Soult, A.S. (2016). Experiences in flipping a large lecture course for general, organic, and biological chemistry *The flipped classroom volume 1: Background and challenges* (pp. 135-145): ACS Publications.

Stott, A. (2004). Issues in the socialisation process of the male student nurse: Implications for retention in undergraduate nursing courses. *Nurse Education Today, 24*(2), 91-97.

Strayer, J.F. (2012). How learning in an inverted classroom influences cooperation, innovation and task orientation. *Learning Environments Research, 15*(2), 171-193.

Tan, C., Yue, W. G., & Fu, Y. (2017). Effectiveness of flipped classrooms in nursing education: Systematic review and meta-analysis. *Chinese Nursing Research*, *4*(4), 192-200.

Talley, C.P., & Scherer, S. (2013). The enhanced flipped classroom: Increasing academic performance with student-recorded lectures and practice testing in a" flipped" stem course. *The Journal of Negro Education, 82*(3), 339-347.

Tanner, M., & Scott, E. (2015). A flipped classroom approach to teaching systems analysis, design and implementation. *Journal of Information Technology Education: Research, 14*, 219-241.

Tawfik, A.A., & Lilly, C. (2015). Using a flipped classroom approach to support problem-based learning. *Technology, Knowledge and Learning, 20*(3), 299-315.

Teo, T.W., Tan, K.C.D., Yan, Y.K., Teo, Y.C., & Yeo, L.W. (2014). How flip teaching supports undergraduate chemistry laboratory learning. *Chemistry Education Research and Practice, 15*(4), 550-567.

Toto, R., & Nguyen, H. (2009). *Flipping the work design in an industrial engineering course.* Paper presented at the Frontiers in Education Conference, 2009. FIE'09. 39th IEEE.

Triantafyllou, E., & Timcenko, O. (2014). *Introducing a flipped classroom for a statistics course: A case study.* Paper presented at the EAEEIE (EAEEIE), 2014 25th Annual Conference.

Tune, J.D., Sturek, M., & Basile, D.P. (2013). Flipped classroom model improves graduate student performance in cardiovascular, respiratory, and renal physiology. *Advances in physiology education, 37*(4), 316-320.

Van Vliet, E., Winnips, J., & Brouwer, N. (2015). Flipped-class pedagogy enhances student metacognition and collaborative-learning strategies in higher education but effect does not persist. *CBE-Life Sciences Education, 14*(3), ar26.

Vaughan, M. (2014). Flipping the learning: An investigation into the use of the flipped classroom model in an introductory teaching course. *Education Research and Perspectives (Online), 41*, 25.

Velegol, S.B., Zappe, S.E., & Mahoney, E. (2015). The evolution of a flipped classroom: Evidence-based recommendations. *Advances in Engineering Education, 4*(3), n3.

Wang, S., & Liu, C. (2018). Task-based flipped classroom in chinese college efl teaching: An empirical study in oral english course. *International Journal of Contemporary Education, 1*(1), 12-18.

Wanner, T., & Palmer, E. (2015). Personalising learning: Exploring student and teacher perceptions about flexible learning and assessment in a flipped university course. *Computers & Education, 88*, 354-369.

Whillier, S., & Lystad, R.P. (2015). No differences in grades or level of satisfaction in a flipped classroom for neuroanatomy. *Journal of Chiropractic Education, 29*(2), 127-133.

Wilson, S.G. (2013). The flipped class: A method to address the challenges of an undergraduate statistics course. *Teaching of Psychology, 40*(3), 193-199.

Wong, T.H., Ip, E.J., Lopes, I., & Rajagopalan, V. (2014). Pharmacy students' performance and perceptions in a flipped teaching pilot on cardiac arrhythmias. *American journal of pharmaceutical education, 78*(10), 185.

Wright, A., Greenfield, G., & Hibbert, P. (2017). Flipped tutorials in business courses *The flipped classroom* (pp. 289-307): Springer.

Xiu, Y., Moore, M.E., Thompson, P., & French, D.P. (2018). Student perceptions of lecture-capture video to facilitate learning in a flipped classroom. *TechTrends*, 1-7.

Yestrebsky, C.L. (2015). Flipping the classroom in a large chemistry class-research university environment. *Procedia-Social and Behavioral Sciences, 191*, 1113-1118.

Yestrebsky, C.L. (2016). Direct comparison of flipping in the large lecture environment *The flipped classroom volume 2: Results from practice* (pp. 1-18): ACS Publications.

Yilmaz, R.M., & Baydas, O. (2017). An examination of undergraduates' metacognitive strategies in pre-class asynchronous activity in a flipped classroom. *Educational Technology Research and Development*, 1-21.

Zainuddin, Z., & Attaran, M. (2016). Malaysian students' perceptions of flipped classroom: A case study. *Innovations in Education and Teaching International, 53*(6), 660-670.

Zappe, S., Leicht, R., Messner, J., Litzinger, T., & Lee, H.W. (2009). *Flipping" the classroom to explore active learning in a large undergraduate course.* Paper presented at the American Society for Engineering Education.

Zeichner, K. (2010). Rethinking the connections between campus courses and field experiences in college-and university-based teacher education. *Journal of teacher education, 61*(1-2), 89-99.