Effectiveness of Flipped Classroom Model in Distance Learning

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Introduction

Flipped classroom**,** a pedagogical model and an alternative to the traditional classroom structure, where the traditional classroom is flipped or inverted by delivering instruction with online materials followed by in-class activities that involve peer learning or small-group work (Ahmed, 2016; Prevalla & Uzunboylu, 2019). In flipped learning students can learn more deeply by engaging themselves with the materials provided in advance outside the classroom and then actively participate with different chosen activities such as discussions, debates, clicker questions, Question and Answer, demonstrations, simulations, peer tutoring and feedback, and role playing (Cummins, Beresford, & Rice, 2016; Estriegana-Valdehita, Plata, & Medina-Merodio, 2017). This reflective and active learning approach can enhance and support undergraduate learning through collaborative group work and increased interaction between students and lecturers (Sivapalan, Clifford, & Speight, 2016).

This model has been adopted in many universities as it delivers prospects for improving peer interaction and deeper engagement with the classroom material (Johnson, Adams Becker, Estrada, & Freeman, 2014). Previous research (Prevalla & Uzunboylu, 2019) stated implementation of flipped classrooms model particularly in engineering education can improve student performance, as it has the potential to assist students to apply theory into practice, become accountable for their learning and prepares them for the challenges likely to be encountered in engineering field (Bishop & Verleger, 2013; Karabulut-Ilgu, Cherrez, & Jahren, 2018). Most often engineering students learn better when they engage in complex problems and projects (Lombardi & Oblinger, 2007) and are reluctant to skip lecturing on theoretical and background information necessary for solving engineering problems (Bishop & Verleger, 2013). Implementation of flipped learning model can bridge these two concepts and improve student learning.

For decades, universities have recognised that students are choosing higher education in engineering to pursue a professional career, where they can improve their knowledge while engaged in employment (Prevalla & Uzunboylu, 2019). Several previous studies (Ceker & Ozdamli, 2016; Estriegana-Valdehita et al., 2017; Karabulut-Ilgu et al., 2018; Prevalla & Uzunboylu, 2019) also indicated a rapid rise in non-traditional and part-time means of providing engineering education, and distance education is a common method for this. With these changes, one sees an ever increasing demand for distance learning or flexible learning to those who otherwise would not be able to complete it (Ceker & Ozdamli, 2016). Flexible education can also benefit potential students on different categories such as people working full-time, living overseas temporarily, travelling for work for long periods of time, not able to come to the university due to disability or illness, and even the incarcerated (Long, Matthew, Joordens, & Littlefair, 2014; Werth & Madritsch, 2019). So the implementation of this blended learning approach in distance learning, where they can get all the study materials online and classroom activities will be via video tutorials or live streaming, and practical work via remote access labs, can improve online student engagement certainly. The continuous development and redesigning of distance education using flipped classroom model will not only be beneficial for the universities but also can help small and medium-sized companies in remote and regional areas to support their employee's lifelong learning and strengthens their position as attractive local employers.

Despite the uptake of the flipped classrooms in other disciplines there is a lack of evidence available about the effectiveness of this model in distance learning on engineering education. Additionally, most of the previous evaluation methods were limited to quantitative data drawn from case studies and there is a scarcity in qualitative research. Therefore, this study aim to review critically the effectiveness of flipped classroom model in distance learning. The outcome of this study will answer the following research questions:

- How the flipped classroom model has been applied in distance learning on engineering education and outcomes associated with this style of teaching?
- What are the main challenges of using flipped classroom approach in distance education?
- How to overcome these possible challenges and implement this model in distance learning?

Method

Article selection strategy

The approach for this systematic search is supported by (Betihavas, Bridgman, Kornhaber, & Cross, 2016) four-stage framework, which adopts: (1) Identifying records through database (2) Screening relevant studies, (3) Eligibility and (4) Inclusion of final studies (Figure 1). To ensure that relevant studies are included in this study, a wide variety of search criteria were used with different combination of keywords which is provided in Table 1. Study selection and inclusion and exclusion criteria were also developed to match the suitability and objective of this study which are discussed in Table 2. The complete article selection process was based on four Scopus search criteria considering all the articles published in the area of engineering between 2000 and 2019. However, articles published in 2019 was removed due to insufficient full year data across Scopus database. Also, articles found to be irrelevant were removed after reviewing the title and abstract, particularly those not in distance learning. The final selection of articles include studies that are mostly relevant to the objective of this paper. The numbers of total articles on each criteria are organized and tabulated according to context and type. Flipped model adopting patterns using different search criteria are identified in Figure 2.

Table 1: Scopus search information

Scopus search	Search 1	Search 2	Search 3	Search 4
Search information	Flipped classroom	Flipped classroom	Blended Learning	Flipped classroom in distance education
Keyword	Teaching	Flipped classroom	e-learning	Distance education
Limit to subject area	Engineering	Engineering	Engineering	Engineering
Limit to source type	Conference proceeding and journals	Conference proceeding and journals	Conference proceeding and journals	Conference proceeding and journals
Studies found	297	218	472	17

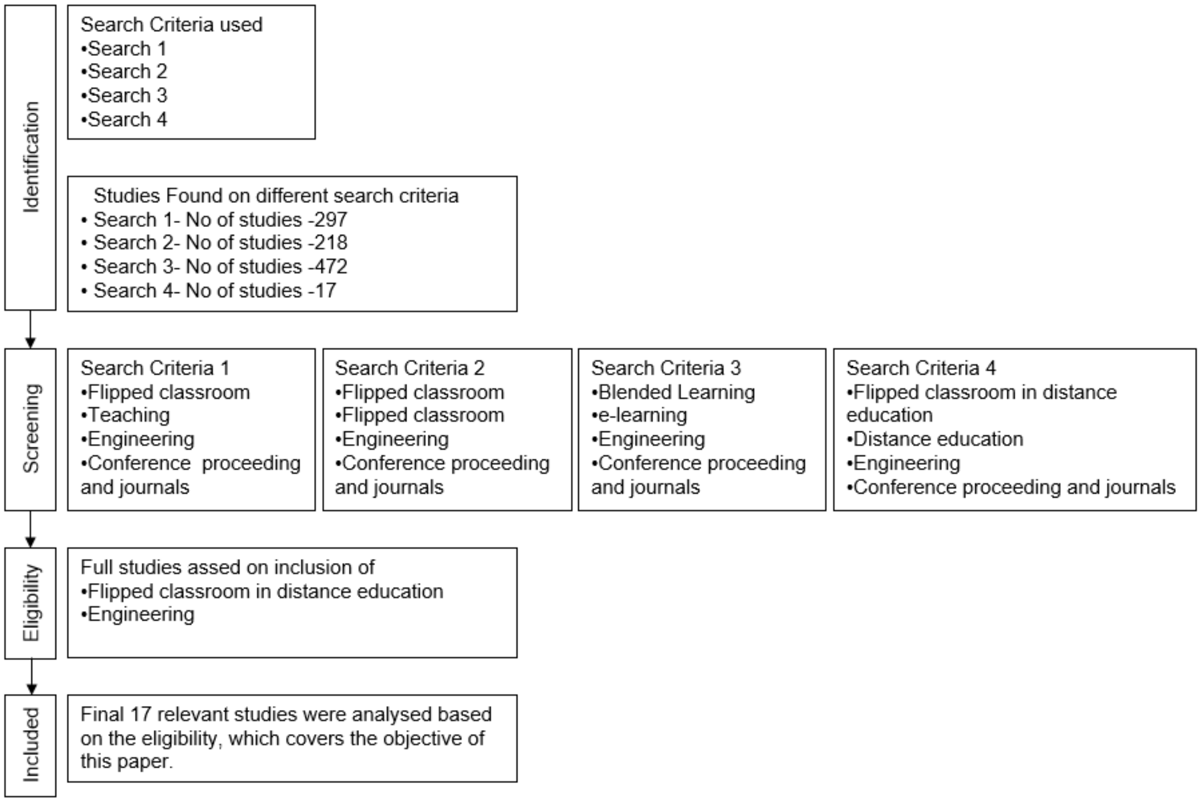

Figure. 1: Flow diagram of the adopted systematic search

Table 2: Inclusion and exclusion criteria

Criteria	**Inclusion**	**Exclusion**
Article type	Peer-reviewed journal and conference paper.	Book series, book and others
Literature type	Articles related to application of flipped classroom model in distance engineering education.	Studies not having useful application of flipped classroom model.
Study Focus	Prospective engineering students in distance education.	All other students.
Discipline focus	Engineering	All other discipline
language	English	Non-English studies
Time period	2000-2019	Studies outside these time frame
People	Students enrolled in distance learning in engineering programs and employers who apply flipped classroom in employment settings.	All other students and employment places that do not apply flipped classroom

Search Outcome

By using the 4 different search criteria, a total of 297, 218, 472 and 17 peer-reviewed journal article and conference papers were found to date for search 1, search 2, search 3 and search

4 respectively. Figure 2 outlines the research trend in implementing flipped learning model on distance engineering education. Figure 2 (b) and (c) clearly shows an increasing numbers of research were conducted to date on application of flipped classroom model or blended learning approach on engineering education. However, only few studies were found using flipped classroom model in distance learning on engineering education, which is also shown in Figure 2 (d).

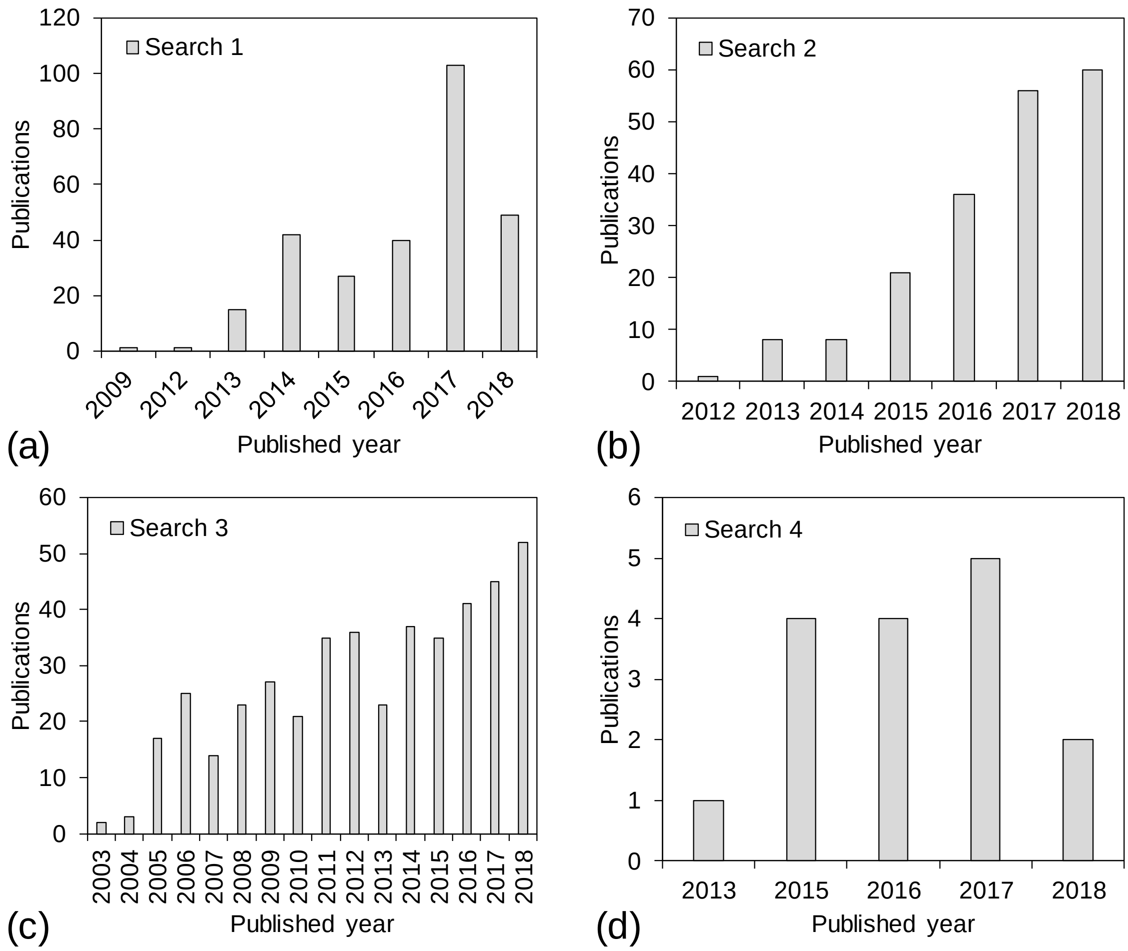

Figure. 2: Publication trend of flipped classroom pedagogical research.

Discussions

This systematic review include selected relevant 17 studies (Figure 1). The findings from these selected studies are organised into the following sections based on the research questions of this study, which include flipped learning activities in distance learning, challenges associated with application of the flipped model and possible solutions to overcome the challenges.

Flipped learning activities in distance learning

Active learning techniques using flipped model have many benefits in which students have to engage in meaningful learning activities and reflect on what they are doing (Prince, 2004). Several types of learning activities were listed as commonly used in the reviewed studies (Battaglia & Kaya, 2015; Chiang & H. Wang, 2015; Estriegana-Valdehita et al., 2017; Prince, 2004) e.g. videos, online study materials through course websites or study desk, virtual labs, circuit simulators and game based learning.

Online study material

Most of the published research in recent years found the implementation of one of the latest educational technology resource with the greatest potential in distance learning, named course website or study desk. It is used in a wide variety of ways; most apparently in distance education (Estriegana-Valdehita et al., 2017; Jo, Jun, & Lim, 2018; Long et al., 2014; Werth & Madritsch, 2019).The information the course websites includes welcome message, announcement and general forums, course overview, study schedule, assessment details, list of teaching staff, online study guide topic by topic or week-by week, assessment submission link etc., from where student can get all course related information not even attending any on campus lecture or tutorial (Long et al., 2014).

Videos

The results of many studies addressed video with other resources, can be used as an effective and useful learning tool for distance learing students. Using instructional strategy to achieve diverse learning objectives and competencies these videos can provide significant knowledge gains (Kay & Kletskin, 2012), student satisfaction and grade improvements (Wells, Barry, & Spence, 2012) and leading to the acquisition of significantly higher practical skills (Donkor, 2010).

Virtual labs and simulators

In engineering, students must utilise their learning time in solving practical problems and improve simulating experiences. Previous studies suggested computer simulation and virtual laboratories can be used as an efficient supplementary tool in distance learning in providing hands-on learning experiences and improving motivation among engineering students (Estriegana-Valdehita et al., 2017; Harb, Harb, & Batarseh, 2015; Sheorey, 2014).

Game based learning

Several authors investigated and reported that game-based learning method has potential to increase student enthusiasm continues to grow in challenging project and involving the students in an active based learning (Auvinen, Hakulinen, & Malmi, 2015; Filsecker & Hickey, 2014; Osipov, Nikulchev, Volinsky, & A. Y. Prasikova, 2015; Weiss, Knowlton, & Morrison, 2002). A previous experimental study (Dominguez, Saenz-de-Navarrete, L. de-Marcos, & Fernandez-Sanz, 2013) on an online game web-based problem-solving activity, with results showing a significantly improved experience in learning attitudes, learning interest and the level of acceptance of technology among the students.

The outcome of this review can further strengthen by incorporating other databases such as Web of Science, Google Scholar and ERIC.

Challenges

Previous research identified the biggest challenge faced by engineering educators in distance learning was to provide students with practical education (Long et al., 2014; Shi, Yuan, & Zou, 2016; Werth & Madritsch, 2019). Mostly in engineering degrees the obvious solution to this problem is to run dedicated practical or lab classes. This require more staff engagements and proper training. Reviewed studies stated engineering schools faced several faculty difficulties and issues associated with distance education which includes: enriching teachers' experiences as a first-time user of flipped classroom approach (Khan & Ibrahim, 2017; Long et al., 2014; Moudgalya, Eranki, Ganguly, Mohanan, & Raja, 2016; Prevalla & Uzunboylu, 2019), course structure, communication with students, delivery of course material, delivery of exams, accreditation, equity between on-campus and off-campus students, and especially the delivery of practical or lab classes. They suggested as a first time user the faculty members who prefer to apply this blending approach would require mentoring to facilitate interaction (El-Banna, Whitlow, & McNelis, 2017; Karabulut-Ilgu et al., 2018). Considering the application of this model on distance learning other operational challenges identified in previous research included infrastructure for remote access labs, weekend classroom availability, access to the library and technology centre and limited high speed internet access for rural students (Estriegana-Valdehita et al., 2017; Howard & Stimpson, 2017; Karabulut-Ilgu et al., 2018).

Implementation

While many previous studies (Betihavas et al., 2016; McLaughlin, White, Khanova, & Yuriev, 2016; Moudgalya et al., 2016; O'Flaherty & Phillips, 2015; Sivapalan et al., 2016) have investigated the effectiveness and impact of online learning on students, only few have considered and indicated Implementation of flipped classroom approach in distance learning.

Over the past few years distance learning has generated considerable interest in engineering departments and more universities are interested in offering their programs by distance education(Long et al., 2014; Moudgalya et al., 2016). The dynamic and rapidly changing nature of engineering education requires prospective students to be well-appointed with skills in problem identifying, problem-solving, critical thinking, information technology and information literacy (Karabulut-Ilgu et al., 2018; McLaughlin et al., 2016).

To achieve these goals and overcome the challenges, engineering curriculum need to shift towards blended learning framework in the context of discipline-based distance learning where nearly all course material is delivered on-line by means of course websites and practical experiences through lab classes, workshops, and work placements. So the academic staff who prefer to implement the flipped classroom can choose this blending approach where nearly all course material can be is delivered on-line through study desk, web-based real-time tutorials videos can be streamed through the study desk and relevant software can be delivered by means of a remote-desktop service, and remote-accessed lab experiments can be employed for providing practical engineering work experiences. Also, the additional challenges for students' practical work experiences in engineering degree can be reduced by introducing video-recorded experiments, weekend lab classes, computer simulations, lab kits and associated at-home experiments ,at-home design projects, web broadcasting of lab classes and an intensive residential school .

Conclusions

The student-centred approach of the flipped classroom provides flexibility and the potential to increase opportunities for students to develop and apply the critical thinking skills which is pre-requisite for engineering degree. The system review on the effectiveness of flipped classroom model in distance learning is timely as this blended approach has gained popularity amongst engineering educators. The review of the mostly relevant articles included in this study has been framed around three major research questions on flipped classroom model. The findings of this study indicates an increasing trend of research using this model in various sub-fields of traditional engineering education, whereas only few studies were conducted regarding its application in distance learning. This indicates, further research is required to examine the implementation of this model in distance learning using possible solutions of the biggest practical work experience challenges which can be achieved by introducing new technologies such as video-recorded experiments, computer simulations, lab kits and associated at-home experiments, at-home design projects, web broadcasting of lab classes and an rigorous residential school.

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