RESEARCH ARTICLE

Widening participation students' experience and perception of flipped learning statistics compared with traditional teaching in higher education

Dr Jinhua Mathias, Foundation programme, Durham Centre for Academic Development, Durham University, Durham UK, Jinhua.mathias@durham.ac.uk
Dr Izabela Walczak, Foundation programme, Durham Centre for Academic Development, Durham University, Durham, UK, izabela.w.walczak@durham.ac.uk
Mr Stephen Leech, Foundation programme, Durham Centre for Academic Development, Durham University, Durham, UK, s.j.leech@durham.ac.uk

Abstract

This paper presents data from a study comparing student experience and attainment when teaching statistics using Traditional Teaching (TT) and Flipped Learning (FL) approaches on a Foundation level module at a UK university. A survey of students' experience and perception of FL was conducted at the end of the year. The results showed that the students liked the flexibility of FL and believed that studying asynchronously encouraged them to improve their independent learning skill and motivated them to search for more information for the subject, a finding broadly supported by other studies (Price and Walker, 2021). However, what was surprising, is that students believed they learned 'better' with TT than with FL, a perception supported by student overall attainment data. The study concludes that careful considerations must be made to make FL effective. These include the student demographic and their mathematics competency, the module contents and difficulty level. Otherwise, the use of FL may reduce students' engagement and academic performance in mathematics at Foundation level.

Keywords: flipped learning, non-traditional students, widening participation, statistics.

1. Introduction and theoretical background of the study

The Covid-19 pandemic has dramatically changed how we work across all sectors of business, including university teaching. Teaching is evolving to further embrace flexible learning to meet the diverse needs of learners and enable them to take more personal responsibility for the learning process. These changes have been possible because of the vast potential of readily and easily accessible information and resources available online, as well as rapid advances in learning technologies that are making online teaching more accessible and engaging. Flexible learning continues growing from technological, pedagogical, and institutional perspectives, and for most universities, the question about flexible learning is not 'if' but about 'how' (Loon, 2022).

One mode of flexible learning is flipped learning (FL), which employs a pedagogical approach in which students learn knowledge asynchronously following instructions from tutor and then apply concepts and engage in the subject matter in a synchronous interactive environment (www.flippedlearning.org). The pedagogical benefits of FL to the learners, as evidenced in many studies, includes improvement in academic performance, cognitive and affective domains (better engagement in learning and higher motivation) and transferable skills (independent and self-regulated learning and time management) (Bond, 2020; Birgili et al., 2021). The current understanding of the effectiveness of this strategy is, however, mostly based on research conducted at secondary school or at undergraduate level on traditional students entering a university through a conventional route; many studies were conducted in Asia (Bond, 2020; Birgili, et al., 2021). Limited attention has been given to how FL impacts on widening participation and non-traditional students.

Widening Participation and non-traditional students, in this context, are comprised of students from under-represented groups in higher education (Laing and Robinson, 2003; OfS, 2020). Many of these students have not gained sufficient skills and subject knowledge required to access degree study, often due to disrupted educations and, therefore, choose a Foundation Year programme as an extra year of study to gain entry to their chosen undergraduate course. Foundation Year programmes are often established within a university specifically as a part of the university's commitment to improving access to higher education from under-represented groups (Laing and Robinson, 2003; Leech and Marshall, 2016).

The teaching on Foundation programmes in many universities has two objectives; the first is to fill the gap between a student's current subject knowledge and the assumed knowledge of their chosen degree programme (i.e., the UK A level content associated with pre-requisite qualifications for standard entry) and the other is to develop a student's cognitive, academic and transferable skills, epistemological maturity, self-regulation, and self-efficacy. In this respect, FL has been shown to positively contribute to developing transferable skills among students such as self-directness and self-management (Cakiroglu and Ozturk, 2017; Narendran et al., 2018). FL can also improve student behavioural and cognitive engagement (Jamaludin and Osman 2014, Huang, et al., 2019).

In this paper, we evaluate Foundation students' experience of being taught statistics using FL and TT approaches, within a research-intensive UK university Foundation Programme in academic year of 2021 - 2022. The aim of the study is to provide responses, evaluations, and recommendations to the following questions:

1. Do Widening Participation (Foundation level) students believe that a FL makes a positive contribution to learning mathematics? The hypothesis is that Widening Participation students would find FL beneficial in improving cognitive and transferable skills.

2. Does the use of FL have a positive impact on student attainment when used to teach mathematics to Widening Participation (Foundation level) students? The hypothesis is that FL would provide Widening Participation students better learning experience, hence improving their attainment in mathematics.

2. Context

The Foundation programme discussed in this paper provides access to a wide range of degree courses for learners from under-represented groups in higher education (OfS, 2020) who need a year 0 course to prepare them for undergraduate studies. These students are classed as Widening Participation students and most are from families with low household income or low socioeconomic status. Demographically, the Foundation group consists of two types of students: those who have had more than 3 years away from education and are returning to study as mature students aged over 21; and another group who completed advanced level (A-level) in school in recent years but did not achieve desired grades for direct entry to the university courses, often due to educational disadvantage.

This study focuses on two groups of students who studied Mathematics 1 (M1) for social sciences and Mathematics 2 (M2) for Business and Biology. The number of students in the M1 group is 30 and in the M2 group is 22. The averages of GCSE grades (graded from 1-9) achieved in both groups are similar, 5.7 for the M1 group and 5.6 for the M2 group.

The study modules contained two themes, algebra and statistics. Each theme was taught for 2 hours per week for 20 weeks. The statistics content, which is the focus of the study, was the same in both modules and was taught by the same tutor. Statistics was chosen as the topic for the study because the subject does not require very high level of algebra skills and the students can study the content with little support. Moreover, there are existing evidence claims that FL positively impacts on learning introductory statistics for undergraduates (Farmus, et al., 2020).

3. Traditional versus Flipped Learning

The research was designed to allow both groups to experience both FL and TT approaches (see table 1), thereby permitting students to reflect on the effectiveness of the FL approach in comparison to TT approach in supporting them to develop transferable skills, improve their emotional and cognitive engagement in learning as well as academic attainment. The M1 group studied descriptive statistics using FL for 10 weeks in the teaching block 1 (TB1) while the same content was taught to the M2 students using TT, then both groups were assessed on the content with an open-book test. The teaching methods were swapped for the following 10 weeks in the teaching block 2 (TB2), followed by an open book test, when teaching inferential statistics.

Table 1. Modes of teaching in M1 and M2 in the 2021-22 academic year.

Statistics content	M1	M2	Assessment
Term 1 (10 weeks): Descriptive analysis	FL	TT	Open book
Term 2 (10 weeks): Inferential analysis	TT	FL	Open book

The teaching cycle of a week for FL typically involved an instructed asynchronous learning activity followed by synchronous learning in a face-to-face classroom setting. The asynchronous activities included an introduction to the topics of the week, the aims, study tasks, and practice questions. The student's preparedness for the synchronous session was assessed at the beginning of each synchronous session using an online voting tool. This was followed by several high cognitive exercises. Optional, weekly online practice was also provided to allow the students to further consolidate their knowledge. The teaching cycle of a week for TT typically involved initial classroom teaching of the week's topics, followed by practice after the class. Students who demonstrated signs of struggle with learning tasks in both groups were provided with one-to-one support by a tutor and offered an additional one-hour optional workshop.

The asynchronous activities required staff to produce many online materials, which can be time consuming (Mason, et al., 2013). MyMaths, an interactive online teaching and homework subscription website, developed by Oxford University press, and tutor pre-recorded videos were used as the source of the learning material for asynchronous activities in the flipped learning teaching. MyMaths resources were also used as non-compulsory consolidation material for the traditionally taught classes. Using interactive lessons designed by MyMaths saved a significant amount of work for tutors who could focus on writing instructions for asynchronous activities and prepare synchronous activities and assessment materials.

4. Evaluation

Student experience was evaluated at the end of the academic year, after 20 weeks of teaching. The questionnaire, sent to all students in M1 and M2, included sections asking students about their transferable study skills (4 items), emotional and cognitive engagement (5 items), and overall experience (3 items). The statements in the questionnaire used a 5-point Likert scale from "strongly disagree" (1) to "strongly agree" (5). The Cronbach alpha, a measure of internal consistency, was 0.94, confirming excellent reliability for the questionnaire. Two free-text questions were included to allow the students to provide open explanations about their experiences. The combined response rate to the questionnaire was 35.2%.

5. Results and discussion

5.1 Transferable study skills

Figure 1 shows the responses to questions regarding attitudes toward FL in relation to opportunities for developing independent study skills, student satisfaction with the pace of learning, the degree to which the learning addressed individual student need, and for developing students' time management skills.

Results indicate that 68.4% of the students agreed or strongly agreed that FL encouraged them to develop independent study skills and that they were satisfied with the pace of learning. Only 5% and 15.8% disagreed or strongly disagreed with these statements, respectively. These results are consistent with Chivata and Oviedo (2018) who found that 87% of undergraduate students agreed and strongly agreed that they liked the flexibility of FL when studying an English subject at the Colombia University. Wilson (2013) suggests that FL strategy creates a feeling of greater accessibility, which is particularly important in the diverse ability cohorts and when teaching subjects, like mathematics and statistics, that often cause anxiety among the students (Wahid et al., 2014).

Only 57.9% and 47.4% of the students agreed or strongly agreed that the asynchronous activities helped them to tailor the learning to meet their needs and improved their time-management skills, respectively. These results are in line with Mason et al. (2013) findings among mechanical engineering students who recognised that the flipped learning strategy required self-discipline and some adjustment to their study habits.

Student's response in the free text also supported what has been found in the questionnaire. In the open-ended comments the students explained that they liked FL activities because

> *"It gives me more time to understand each mathematical concept. Or to speed up certain parts of the video if needed."*
>
> *"Allowed you to pick and choose which topics to learn more about before the lesson."*
>
> *"Flipped learning allows the brain to digest what you are going to further go over in the classroom"*

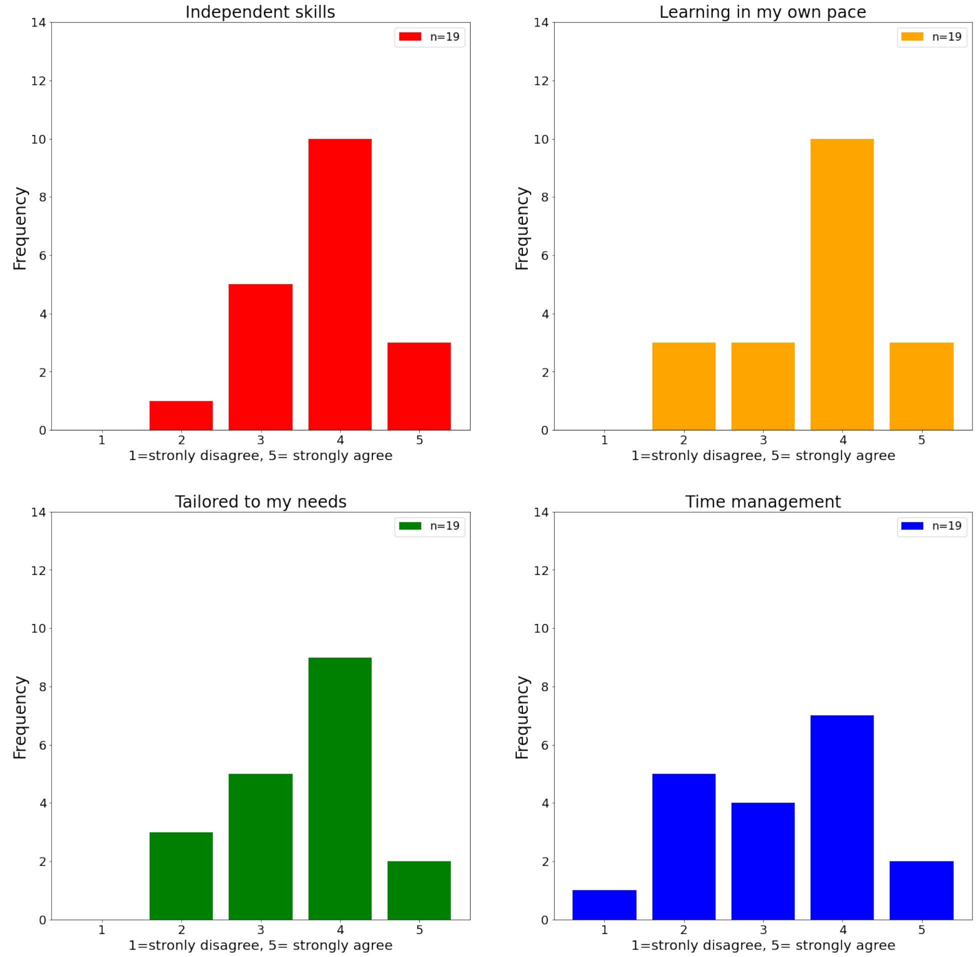

Figure 1. Students' response to the questionnaire regarding study skills

5.2 Emotional and cognitive engagement

Responses to questions about the impact of asynchronous sessions on emotional and cognitive engagement was also positive, as shown in figure 2. Results show that 68% of students agreed or strongly agreed that the asynchronous activities encouraged them to actively search for more information about the subject matter, compared to 26% who disagreed or strongly disagreed. In addition, 79% agreed or strongly agreed that the asynchronous activities were effective in helping them to prepare for the synchronous sessions compared to 21% who disagreed or strongly disagreed.

In relation to student understanding, 58% of students agreed or strongly agreed that studying asynchronous activities made synchronous sessions easier to understand compared to 26% who disagreed or strongly disagreed. Finally, 68% agreed or strongly agreed that studying asynchronous activities encouraged them to attend synchronous sessions compared to 21% who disagreed or strongly disagreed. In the open-ended comments the students explained that they liked FL's asynchronous activities because:

> *"It encouraged exploring the topics within different forms of media such as YouTube."*
>
> *"It gave me a chance to prepare before class, so I understood more"*
>
> *"They made me feel more confident"*

However, the data also shows that, in general, the students did not think that the FL approach to teaching mathematics improved their interests in mathematics; only 47% of the students agreed or strongly agreed that studying FL activities made synchronous sessions more interesting, whilst 26% were not sure and the remaining 26% disagreed. This contradicts other studies, which suggest that students who were taught using FL strategy found the module more interesting in comparison to cohorts taught using the traditional methods (Price and Walker, 2021). The reason for these inconsistencies could be that Foundation students in this paper have chosen to study degrees with lower mathematical demands and were less interested in mathematics to start with.

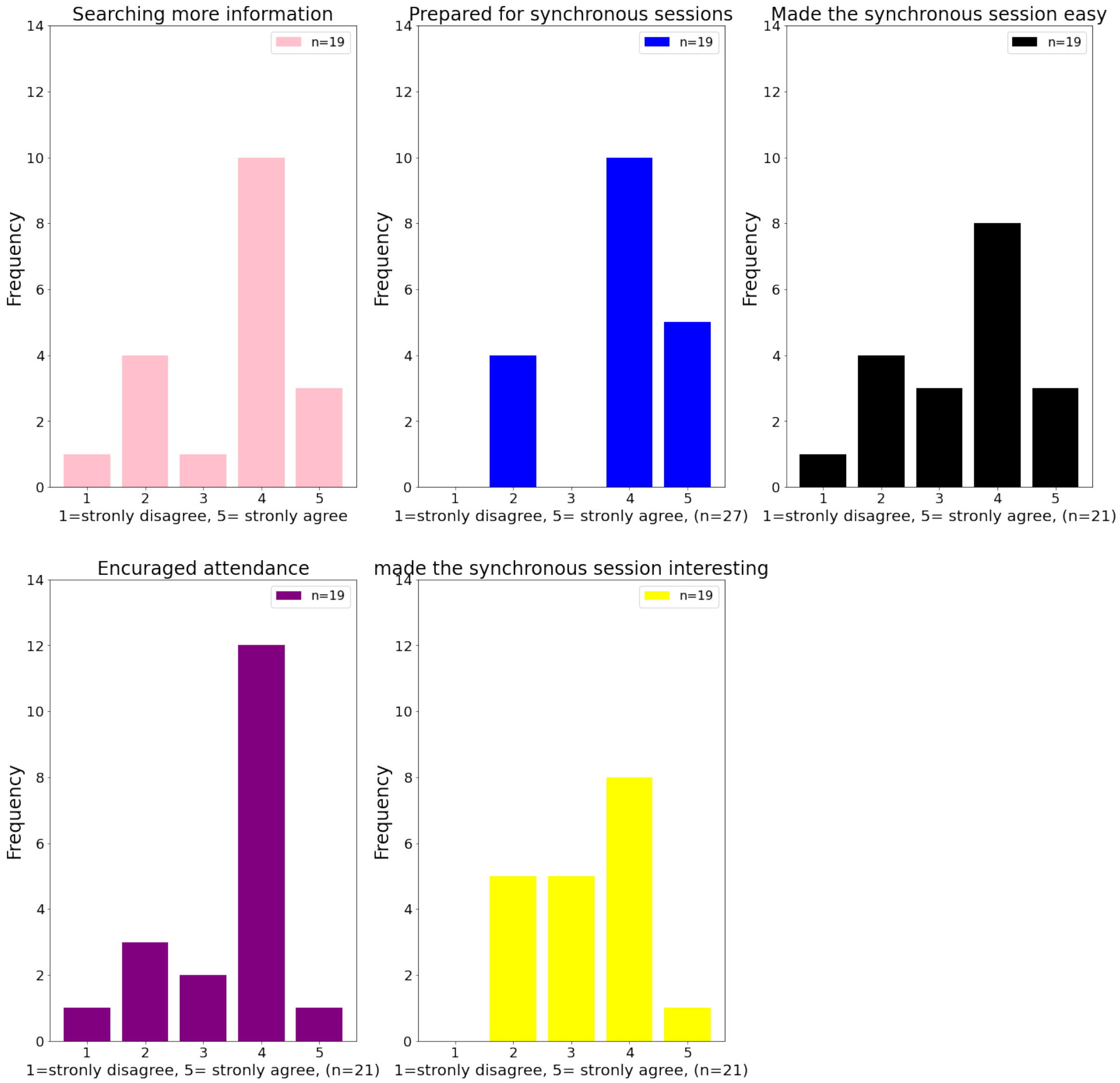

Figure 2. Students' response to the questionnaire regarding emotional and cognitive engagement

5.3 Overall student satisfaction and attainment

The students' responses to their overall satisfaction with FL is shown in figure 3. The results show that 63% of students were satisfied with FL, however, only 42% indicated that they preferred and learned better over the FL in future study. Responses to the open-question on satisfaction with FL revealed that some students felt frustrated when they were not able to ask a question or receive immediate support when engaging with the asynchronous preparation activities as the asynchronous work *"...could frustrate me if I didn't understand"* and *"I prefer, having had difficulty with maths in the past, to be able to ask questions at the time I'm doing the work or I can find myself stalling or unable to continue. So, I preferred the face-to-face sessions in this module. Having said that I think that flipped learning is something I could enjoy doing in my degree pathway next year*." This is somewhat at odds with an observed under-use of the support made available to students.

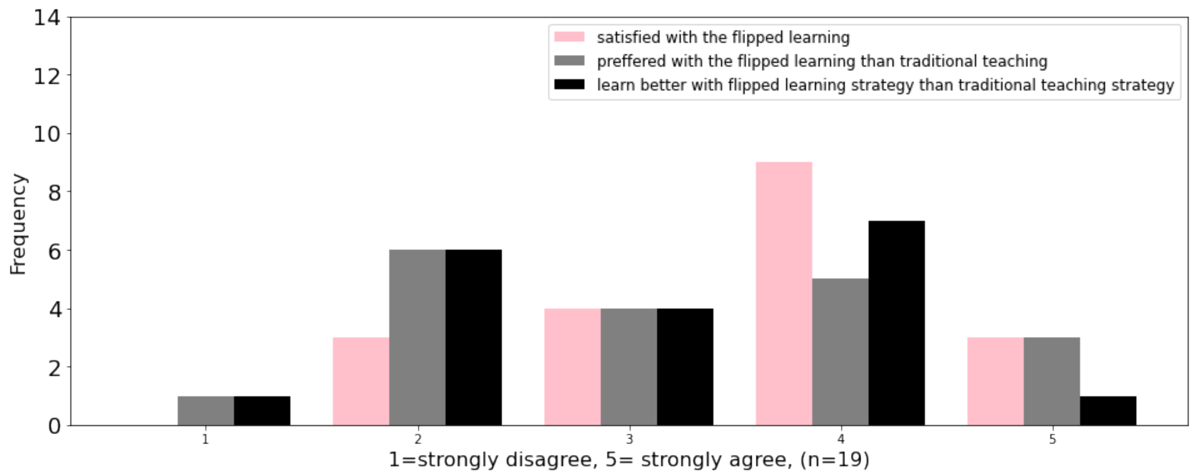

Figure 3. Students' response to the questionnaire regarding overall experience for FL

Table 2 compares student attainment in both groups on statistics assessments. Results show that there was no significant difference between the performance of the two groups using FL or TT when learning descriptive statistics. However, the M2 group achieved lower marks (67.3%) on inferential analysis comparing to the M1 group (73.5%). Although the mark difference is not statistically significant, the 6% gap between the groups cannot be ignored considering both groups have the same level of mathematical skills at the entry of the study.

Table 2. Performances on the statistics of the students in 2021-22

Group*	**M1 (n=30)**	**M2 (n=20)**	**M1 (n=23)**	**M2 (n=16)**
Mean of the GCSE at entry of the study (sd)	5.5 (1.47)	5.6 (1.49)	5.3 (1.81)	5.7 (1.57)
Assessment content	**Descriptive statistics**		**Inferential analysis**	
Mean mark (%)	73.9 (s.d.=16.0) (FL)	73.7 (11.0) (TT)	73.5 (20.1) (TT)	67.3 (17.4) (FL)
p-value (Two sample independent t-test)	0.957		0.313	
Cohen's effect size	0.016		0.333	

* Only the students that completed the tests were included in the means.

The lower performance of the M2 students in inferential analysis raises an important question on what type of knowledge should be flipped and what level of cognitive skills is required for learning the knowledge. Chaeruman (2018) proposed a model of criteria for determining appropriate FL strategy using literatures applied to a revised Bloom's Objective Taxonomy and stated that asynchronous activities should be limited to tasks that are easy to manage individually and require low level cognitive skills, which in turn, should be developed further in synchronous sessions (figure 4). It may be that the level of cognitive skill required for inferential analysis is outside of the range suitable for asynchronous activities used as part of the FL approach noting, that the level of cognitive skills required for the same knowledge could be different depending on the student's previous experience.

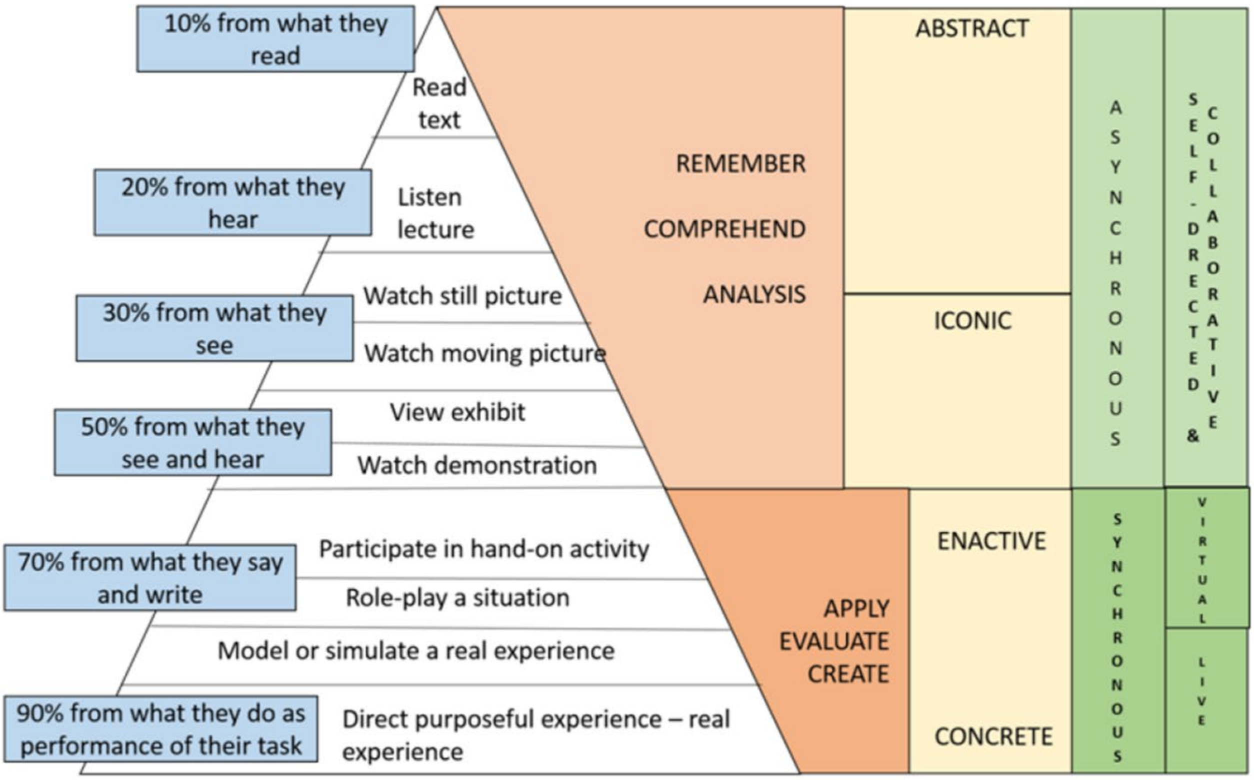

Figure 4. Model of criteria for determining appropriate blended learning strategy (Chaeruman et al., 2018)

Farmus (2020) reviewed literatures on the FL in introductory statistic course for undergraduate students and the results indicated that FL led to statistically higher student attainment than TT. However, all the studies were on undergraduate students who would be competent in mathematics comparing to the Widening Participation students in this study. Moreover, in another example of their highly cited study, Wilson (2013) reflected that although attempts were made to flip all the content when teaching statistics, what was achieved was a half or three quarters flip, and a lot of time was spent summarising the asynchronous course material during the synchronous sessions. This suggests that the design of FL may be limited by the cognitive skills necessary for independently study of the asynchronous materials which FL. Perhaps the balancing asynchronous and synchronous activities requires a tentative, an iterative process, where the teacher can carefully oversee students learning experience and performance and adjust the balance accordingly.

6. Summary and limitations

The first aim of the study is to examine if FL makes a positive contribution to learning mathematics for Widening Participation (Foundation level) students. This study showed that about two-thirds of Foundation students liked FL in general, reporting that FL encouraged independent study skills, allowed them to study at their own pace, motivated them to search for information on their subjects, and to build up their confidence for synchronous face-to-face class activities. This confirms the hypothesis that Widening Participation (Foundation level) students would find that a FL positively contributes to their learning of mathematics. These results broadly agree with the literature (Price and Walker, 2021) and show that FL can benefit Widening Participation (Foundation) students as they transition into HE, encouraging them to develop independent study skills and increasing emotional and cognitive engagement with mathematics.

The second aim is to question if the use of FL has a positive impact on student attainment when used to teach mathematics to Widening Participation (Foundation level) students. It was hypothesised that FL would improve student attainment or, at very least, would not have negative impact on them. However, the study demonstrated the contrary when assessing student attainment on inferential statistics. Therefore, careful consideration should be given to which modules and content can be taught using FL strategy. Firstly, this study advises that not all types of knowledge are suitable for asynchronous activity, and clear consideration should be given to students' cognitive ability and their academic skills; Chaeruman's model of criteria for determining appropriate content and difficulty level for asynchronous sessions may be useful in this regard. Additionally, the FL approach should be considered as an iterative approach, with consideration given to how real-time adjustments can be made to the volume and difficulty level of asynchronous activities; obtaining regular feedback from the students when teaching may help to address this issue and align the FL approach with the student's competency, knowledge, and cognitive skills. Thirdly, appropriate training should be provided to those who may struggle with time management due to the importance of self-regulated learning strategies with FL delivery (Gronlien et al., 2021). As it was mentioned earlier that demographically Foundation students most are from families with low household income or low socioeconomic status, many of these students may have not gained sufficient skills for academic study, often due to disrupted educations. Therefore, time management training may help to raise student awareness of the expectations of FL learning and to help them understand asynchronous study does not mean they must manage the study completely on their own (i.e. they should take advantage of additional support opportunities). Lastly, this study suggests that not all students naturally embrace FL.

The authors recognise that the study has limitations. This study took place at a Foundation programme in a research-intensive university, the structure of the programmes may be different at different HEIs. The number of students who responded to the questionnaire was small and does not represent the full programme cohort. However, the overarching purpose of this article was to draw colleagues' attention to the use of FL in teaching mathematics to students from Widening Participant backgrounds and to discuss the potential benefits and challenges. It is no longer feasible to consider university students as a homogenous group and there remains work to do in finding appropriate teaching strategies to support accessibility for the increasing diversity of students.

7. References

Birgili, B., Seggie, F. N. & Oğuz, E., 2021. The trends and outcomes of flipped learning research between 2012 and 2018: A descriptive content analysis. *Journal of Computers in Education,* 8(3)**,** pp 365-394. DOI: http://doi.org/10.1007/s40692-021-00183-y

Bond, M., 2020. Facilitating student engagement through the flipped learning approach in K-12: A systematic review. *Computers & Education*, *151*, p.103819. https://doi.org/10.1016/j.compedu.2020.103819

Cakiroglu, U. & Ozturk, M., 2017Flipped classroom with problem based activities: Exploring self-regulated learning in a programming language course. *Journal of Educational Technology & Society,* 20(1)**,** pp 337-349. https://www.jstor.org/stable/pdf/jeductechsoci.20.1.337.pdf

Chaeruman, U. A., Wibawa, B. & Syahrial, Z., 2018. Determining the appropriate blend of blended learning: A formative research in the context of Spada-Indonesia. *American Journal of Educational Research,* 6(3)**,** pp 188-195. DOI: https://doi.org/10.12691/education-6-3-5

Chivata, Y.P. and Oviedo, R.C., 2018. EFL Students' Perceptions of Activeness During the Implementation of Flipped Learning Approach at a Colombian University. *Gist: Education and Learning Research Journal*, (17), pp.81-105. DOI: https://doi.org/10.26817/16925777.436

Farmus, L., Cribbie, R. A. & Rotondi, M. A., 2020. The flipped classroom in introductory statistics: Early evidence from a systematic review and meta-analysis. *Journal of Statistics Education,* 28(3)**,** pp 316-325. DOI: http://doi.org/10.1080/10691898.2020.1834475

Gronlien, H.K., Christoffersen, T.E., Ringstad, Ø., Andreassen, M. and Lugo, R.G., 2021. A blended learning teaching strategy strengthens the nursing students' performance and self-reported learning outcome achievement in an anatomy, physiology and biochemistry course–A quasi-experimental study. *Nurse Education in Practice*, 52, p.103046. DOI: https://doi.org/10.1016/j.nepr.2021.103046

Huang, B., Hew, K. F. & Lo, C. K., 2019. Investigating the effects of gamification-enhanced flipped learning on undergraduate students' behavioral and cognitive engagement. *Interactive Learning Environments,* 27(8)**,** pp 1106-1126. DOI: http://doi.org/10.1080/10494820.2018.1495653

Jamaludin, R. & Osman, S. Z. M., 2014. The use of a flipped classroom to enhance engagement and promote active learning. *Journal of education and practice,* 5(2)**,** pp 124-131. https://core.ac.uk/download/pdf/234635267.pdf

Laing, C. and Robinson, A., 2003. The withdrawal of non-traditional students: Developing an explanatory model. *Journal of Further and Higher Education*, *27*(2), pp.175-185. DOI: http://doi.org/10.1080/0309877032000065190

Leech, S., Marshall, C.A. and Wren, G., 2016. Understanding Foundation Year Provision. In *Widening Participation, Higher Education and Non-Traditional Students* (pp. 19-40). Palgrave Macmillan, London. DOI: https://doi.org/10.1057/978-1-349-94969-4_2

Loon, M., 2022. Flexible learning: a literature review 2016-2021. Advance HE. Available at: https://www.advance-he.ac.uk/knowledge-hub/flexible-learning-literature-review-2016-2021

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), pp 430-435. DOI: http://doi.org/10.1109/TE.2013.2249066

Narendran, R., Almeida, S., Coombes, R., Hardie, G., Quintana-Smark, E., Zaher, N., Wang, H.-L., Chowdhury, A. & Stevenson, B., 2018. The role of self-determination theory in developing curriculum for flipped classroom learning: A Case Study of First-Year Business Undergraduate Course. *Journal of University Teaching & Learning Practice,* 15(5), pp 6. DOI: https://doi.org/10.53761/1.15.5.6

OfS 2020. Preparing for degree study: Analysis of Access to Higher Education Diplomas and integrated foundation year courses. Office for Students. Available at: https://www.officeforstudents.org.uk/publications/preparing-for-degree-study/

Price, C. & Walker, M., 2021. Improving the accessibility of foundation statistics for undergraduate business and management students using a flipped classroom. *Studies in Higher Education,* 46(2), pp 245-257. DOI: http://doi.org/10.1080/03075079.2019.1628204

Wahid, S. N. S., Yusof, Y. & Razak, M. R., 2014. Math Anxiety among Students in Higher Education Level. *Procedia - Social and Behavioral Sciences*, 123, 232-237. DOI: https://doi.org/10.1016/j.sbspro.2014.01.1419

Wilson, S.G., 2013. The flipped class: A method to address the challenges of an undergraduate statistics course. *Teaching of psychology*, *40*(3), pp.193-199. DOI: http://doi.org/10.1177/0098628313487461