Does Flipped Classroom Design Enhance Student Learning? Analysis of an Undergraduate OM course

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Abstract

Within higher education, there is a shift away from lecture-based passive learning approaches towards more active ones, such as the flipped classroom. This study focuses on a specific component of flipped designs, particularly online video lecturettes, to investigate their impact on learning gain that refers to the learning of students during the course. The data are from the formal assessments of 389 undergraduate students taking a first year Operations Management course in a UK-based global top-50 business school. The data were analysed through correlations by SPSS (version 23) software. The empirical results indicate that video lecturettes improve students' learning gain.

Keywords: Teaching and Learning in Operations Management; Technology Management in Operations; Service Operations Management

Introduction

Lectures enable universities to educate large classes, allowing them to live up to their perceived role of providers of higher education to masses (Hornsby and Osman, 2014; Maringe and Sing, 2014). However, lectures have been identified as counterproductive for students' learning due to the lack of two-way communication in the classroom (King, 1993, 1994). This drawback is evident in student performance: lecturing large classes of students produces significantly worse learning outcomes than individual tutoring (Bloom, 1984; Cuseo, 2007; Maringe and Sing, 2014). Educational scholars have long sought to solve this challenge (e.g., Michaelsen *et* al., 1982; King, 1993; Mazur, 1997); however, lecturing still dominates educational delivery in universities. Service providers in other industries have managed to solve a similar challenge of providing good quality service to a mass audience through a combination of process redesign and the use of process automation technologies. For example, banking, travel, retail and tax services have been

transformed to a model where processes are redesigned and delivered through the innovative use of Internet and communication technologies (ICT). In higher education, a recent development that resembles these is the application of flipped classroom/learning together with ICT enabled content delivery. In particular this refers to replacing (parts of) mass lectures with pre-recorded video lecturettes (i.e. short videos) that can be accessed by the students independently of time and location.

The flipped classroom (Bergmann and Sams, 2012) as a pedagogic approach provides improved student engagement, customization of learning and productivity in higher education (Finne, 2018). However, there is still a need to evaluate how the approach may help improving students' learning gain (McGrath et al., 2015). Learning gain can be defined as 'distance travelled' or learning acquired by students when comparing two points of their academic career (McGrath et al., 2015). Accordingly, this research examines the learning gain of using the flipped classroom in an undergraduate Operations Management course. For simplicity, the focus is on one of the flipped design's central elements, video lecturettes (see Bergmann and Sams, 2012) that partially replaced lectures. Learning gain in this research is measured as assessment performance. The next section explicates the background for the research.

Flipped design and the use of video lecturettes to improve learning

The main aim of higher education is to deliver value in the form of students' learning (Barr and Tagg, 1995). This requires students to engage with course materials, their peers and the instructor, which can be challenging in the current reality of lectures. In large classes, students may feel a lack of possibilities for accessing the instructor to ask questions and discuss more challenging topics (Carbone and Greenberg, 1998; Cuseo, 2007; Maringe and Sing, 2014). In particular, large classes do not allow the instructor to spend the time with each student that would be required to address their individual needs to facilitate learning (Allais, 2014; Prosser and Trigwell, 2014; Snowball, 2014). Large classes can also easily lead to a situation where students are unprepared and unmotivated for the class as a result of lacking accountability and reduced possibilities for informal assessment of learning (Michaelsen et al., 1982; Carbone and Greenberg, 1998; Cuseo, 2007; Mulryan-Kyne, 2010). Further, especially challenging may be the development communication, critical thinking and problem-solving skills (Michaelsen et al., 1982; Carbone and Greenberg, 1998; Hornsby and Osman, 2014), partly as a result of fewer possibilities to account for individual issues such as cultural diversity in the class (Cuseo, 2007; Mulryan-Kyne, 2010; Milman, 2012; Maringe and Sing, 2014).

The roots of the ideas behind Flipped learning align with Bloom's (1956) studies considering the ways in which different educational approaches allow building students' cognitive skills. Flipped learning has been implemented in fields such as Mathematics (e.g. Love *et al*., 2014), Physics (e.g. Meltzer and Manivannan, 2002), Engineering (e.g. Chao *et al*., 2015; Velegol *et al*., 2015), Economics (e.g. Roach, 2014), Medicine (e.g. Khanova *et al*., 2015), Media (e.g. Enfield, 2013) and in Business studies (Arbaugh, 2005; Arbaugh and Benbunan-Finch, 2006; Armstrong and Sadler-Smith, 2008). Recently, the Internet and ICT were identified as possible ways of delivery (e.g. Arbaugh 2005, Wu and Hwang, 2010), not only for lecturing but also for collaboration-focused education (Arbaugh and Benbunan-Fich, 2006). This revealed possibilities to make education available on demand, independent of time and location (Proserpio and Gioia, 2007; Armstrong and Sadler-Smith, 2008). When Internet-based delivery is combined with in-class education, new possibilities for designing the interaction in- and outside-class emerge. In particular, along with the original ideas, pure content delivery can be relocated outside the classroom, and thanks to technology this can take place in Internet (Arbaugh

2005; Love *et al*., 2014; Roach, 2014). Further, classroom time can be spent on more challenging learning tasks when students will have the instructor available to inspire and help (Auster and Wylie, 2006; Bliemel, 2014).

In particular, the introduction of video lecturettes can allow students to acquire theoretical knowledge independently without the need to involve the instructor directly (e.g., Love et al., 2014; Chao *et al*., 2015). This allows students to come prepared to the class, equipped with knowledge to be ready for more challenging discussions (Khanova *et al*., 2015). Further, those students that may have missed some of the learning in-class can still catch up with others viewing online materials on their own time (Enfield, 2013; Roach 2014). In addition, students that were more engaged in-class can deepen their understanding through the video lecturettes, viewing those as frequently as preferred (Love *et al*., 2014; Khanova *et al*., 2015) which reduces the need for the instructor to repeat contents in-class (Enfield, 2013). The video lecturettes also remove pure content delivery from the lectures so that more time can be spent on engaging learning students (Khanova *et al*., 2015). Some students may though view the combination of video lecturettes and more emphasis on students' own responsibility to learn as undermining the support received (Enfield, 2013).

Flipped learning is often used in conjunction with formative online quizzes or review questions that are expected to incentivise learning in a timely manner and throughout the course (Khanova *et al*., 2015; Velegol *et al*., 2015), thereby providing a balanced cognitive load for students. The quizzes motivate students to view the videos as they see a clear link between the video contents and quiz questions (Enfield, 2013). Accordingly, flipped learning may incentivise students to learn throughout the course rather than a heavy focus on revisions just before the exam (Khanova *et al*., 2015). However, the focus of this paper is narrower: to see how the engagement with bi-weekly video lecturettes may improve assessment performance. Further, the empirical part of this study focuses on the implications of the addition of 23 video lecturettes on an undergraduate Operations Management (OM) class.

When adopting the flipped classroom method, teachers need to make sure that lower performing students do not lose their attention span with this method. Asarta and Schmidt (2017) compared two versions of the same course to see whether flipped design serves all students equally: one delivered in a traditional and one in flipped manner. They found flipped design with video lecturettes produced mixed results on learning: generally lower performing students (judge based on overall course mark averages) received lower marks in flipped design, while generally better performing students received higher marks in the flipped course compared to the traditionally delivered course. This would indicate that the flipped design serves well high performing students while low performing ones suffer. This is in line with Hibbard *et al*. (2015), who found that the downside of the approach might be that the instructor was not available for answering to questions for the video lecturette contents. However, this should not be a problem, if flipped design is appropriately adopted; the idea in flipped classroom is that the students can ask their questions later in the classroom.

The use of instructional videos may have positive effects on student attitudes and performance (e.g. Alpay and Gulati, 2010). However to achieve this potential in a flipped design, constructive alignment of online and face-to-face elements is central for the learning experience. In particular, lecturers should design the module content so that online and lecture material is coherent and structured in a meaningful and clear manner. Strayer (2012) identified that 'ill-connected' online and face-to-face components resulted in lack of motivation and engagement on the part of the students towards the flipped module. Nielsen (2011) points out to the dangers of not adopting the classroom

environment to reflect the flipped classroom's objective of student-centred active learning. The criticism extends on excessive use of online videos without proper introduction and accessibility (Nielsen, 2011) and when videos are used as a complete substitute for 'traditional' lectures (Srigley, 2016).

Hibbard *et al*., (2015) found flipped designs produce better learning outcomes than traditional course designs. Furthermore, students prefer flipped design to traditional teaching (Gilboy *et al.,* 2015; Hibbard *et al*., 2015). Gilboy *et al*. (2015) identified that three quarters of students preferred watching the video lecturettes instead of attending lectures. In addition, more than 60% of students felt their learning was improved. Hibbard *et al*. (2015) reached similar results in their study; 81% of the students reported that they had an improved motivation to learn and 87% reported that they did indeed learn from the video lecturettes. Flipped classroom design requires students to acquire basic knowledge and comprehension using online video lecturettes. These facilitate the acquisition of foundational knowledge such as terminology and basic concepts. The time spent with the instructor in the classroom is then used to apply this foundational knowledge (Bergmann and Sams, 2012; Finne, 2018). Examination of the efficacy of flipped learning in tertiary education is in its infancy and there is little research that examines whether the breadth of content viewed and the number of times the content is viewed influence assessment performance. Accordingly this research tests the following two hypotheses:

H_1: *Covering a greater breadth of video lecturettes positively influences assessment performance in assessments corresponding to the contents of the specific video lecturettes.*

H_2: *Revising course contents through viewing a video lecturette several times positively influences assessment performance in assessments corresponding to the contents of the video lecturette.*

Methods

A first year undergraduate Operations Management course was analysed in a UK-based global top-50 business school. The data are from 2016, when the course adopted a flipped classroom design using 23 video lecturettes that were arranged into four content blocks. Within each block, topics were recorded as short videos usually spanning between 5 to 10 minutes. The video content was essentially based on the core or threshold concepts (Meyer and Land, 2003) of OM. These concepts (such as 4Vs and input-output model) are central to the mastery of the OM subject and enable the student to begin thinking as an operations manager. Students were assessed five times through the course, four multiple choice, online tests (comprising a total of 25% of the final mark) and one one-and-a-half-hour exam (75% of the final mark). The sample size is 389 students and the data include the number of times video lecturettes were viewed with the respective assessment performance of the student in terms of tests and essay exams. Learning gain was studied through analysing the correlations between video views and exam performance, as hypothesized by H_1 and H_2. The variables of the study are presented in table 1.

Table 1 – The variables and their descriptions.

Type	Description	Variable
Independent variables: Video lecturette views	The percentage of available video lecturettes that a particular student viewed within a content block	Block1_percent
		Block2_percent
		Block3_percent
		Block4_percent
	The number of times that a particular student viewed the same video lecturette	Block1_per_video
		Block2_per_video
		Block3_per_video
		Block4_per_video
Dependent variables: Assessment performance	Performance in four multiple choice tests during the course	Test1_results
		Test2_results
		Test3_results
		Test4_results
	Performance in multiple choice questions of the final exam	Exam_Section_A
	Performance in essay question of the final exam, which was based on content block video lecturettes	Exam_QB1_blocks
Control variable	Performance in guest lecture based essay question of the final exam	Exam_QB2_guest

The data were analysed through correlations in SPSS version 23. Further and more detailed analysis on the data is planned to be carried out in the next phases of research.

Results

The results summarized in Table 2 show that students were engaged in watching the videos lecturettes throughout the studied course. In the beginning of the course, in block 1, students watched 95.5% of the available video lecturettes on average. In blocks 2, 3 and 4, the students continued engaging with a broad range of the videos, as the averages ranged from 94.3 to 95.1% videos covered. Furthermore, students revised their learning through watching videos, which was identified through repeated views of the same videos. In block 1, the average time an individual student watched the same video lecturette was 4.102 per video, while in block 2 the average was 5.047, in third block 4.498 and in fourth block 4.892.

Table 2 presents also the correlations between the percentage of videos viewed and student performance in four multiple tests, each based on a particular content block. In addition, the correlations between the number of times that a particular student viewed the same video lecturette and the performance of students in the tests are presented. Furthermore, the correlations between percentage of videos watched and final exam scores are included, as well as the correlation between the number of times videos viewed and final exam scores. Moreover, the correlations between the extent of video lecturettes covered and the final exam results of sections related to guest lectures are presented, as

well as the correlations between the number of times videos watched and final exam scores of sections related to guest lectures are presented.

The main results are briefly discussed next, and the expected correlations are highlighted in Table 2 through using bold font and the correlations with the control variable through using underlined font. First, a significant positive relationship was identified between the percentage of video lecturettes watched and all of the four test scores. This would indicate that covering a larger extent of videos may lead to better performance in assessments. Second, there was a significant positive relationship between the number of times videos watched and the test scores in all of the four tests except in the test 3. Accordingly, revision through repeated video lecturette view would seem to improve performance in blocks 1, 2 and 4. Third, in blocks 2 and 4 there was a significant positive relationship between the percentage of videos watched and final exam scores (section A), as well as in blocks 1, block 2 and block 4 there was a significant positive relationship between watching the videos several times and final exam performance (section A). These indicate the improvements in multiple choice questions of the exam achieved through watching the video lecturettes. Finally, watching videos did not seem to contribute to study performance in questions related to gest lectures (Exam_QB2_guest), except from covering a greater extent of block 3 video lecturettes. This is understandable as the exam questions on guest lectures were intentionally designed so that the students would have to directly discuss the aspects covered by the guest lecturers. The guest lecturers were not included in the video lecturettes, rather hey took place in class.

Table 2 – Summary statistics and correlation coefficients (bold indicates expected correlations, while underlined a correlation with the control variable).

	Variable	n	Min	Max	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Block1_percent	389	.00	100.00	95.501	20.124	1														
2	Block1_per_video	389	.00	14.00	4.102	2.457	.363**	1													
3	Block2_percent	389	.00	100.00	94.674	20.780	.841**	.351**	1												
4	Block2_per_video	389	.00	21.00	5.074	3.042	.337**	.762**	.390**	1											
5	Block3_percent	389	.00	100.00	94.312	21.261	.834**	.350**	.879**	.367**	1										
6	Block3_per_video	389	.00	20.10	4.498	2.756	.322**	.689**	.351**	.785**	.406**	1									
7	Block4_percent	389	.00	100.00	95.051	21.152	.841**	.342**	.884**	.364**	.849**	.345**	1								
8	Block4_per_video	389	.00	22.50	4.892	3.134	.318**	.637**	.347**	.748**	.366**	.778**	.358**	1							
9	Test1_results	379	.00	100.00	64.670	18.071	**.318****	**.142****	.328**	.115*	.304**	.141**	.372**	.116*	1						
10	Test2_results	379	.00	100.00	75.831	21.095	.345**	.117*	**.431****	**.182****	.423**	.199**	.379**	.116*	.550**	1					
11	Test3_results	379	.00	100.00	72.639	20.260	.296**	.011	.390**	.061	**.298****	**.065**	.352**	.008	.356**	.428**	1				
12	Test4_results	380	.00	100.00	84.237	20.071	.292**	.040	.364**	.075	.343**	.088	**.377****	**.109***	.285**	.264**	.315**	1			
13	Exam_Section_A	369	12	82	49.22	12.333	**.093**	**.105***	**.180****	**.139****	**.142****	**.091**	**.092**	**.137****	.109*	.164**	.167**	.228**	1		
14	Exam_QB1_blocks	248	12	89	42.69	14.467	**.125***	**.159***	**.100**	**.138***	**.156***	**.172****	**.097**	**.116**	.211**	.229**	.172**	.153*	.100	1	
15	Exam_QB2_guest	121	12	81	44.90	12.761	.016	-.065	.069	.017	.187*	.048	.058	.132	-.086	.085	.080	.064	.300**	.[c]	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).
c. Cannot be computed because at least one of the variables is constant.

Both H_1 and H_2 were supported by the empirical results. The results support the hypothesized relationships, particularly that both a wider coverage of video lecturettes and repeated viewing lead to better assessment performance. However, the identified links were stronger when performance was measured in the biweekly multiple-choice tests throughout the course. The relationship with exam performance was weaker, even though mostly significant: five out of eight relationships were significant ($p<0.05$). both for multiple choice questions and essay question in the final exam. Based on the results, there is a statistically significant ($p<0.01$) positive relationship between watching video lecturettes and assessment performance in in the multiple choice tests. Furthermore, revising course contents through viewing a video lecturette several times increases assessment performance in the multiple choice tests in blocks 1, 2 and 4 ($p<0.05$).

Discussion

This work contributes to the studies on the effectiveness of flipped classroom as an approach to provide education (e.g. Bergmann and Sams, 2012; Finne, 2018). Further, the study yields novel insights into contemporary discussions regarding the learning gain (McGrath *et al*., 2015). Studies on flipped classroom design are emerging, with anecdotal and subjective evidence reported more frequently than numerical or statistical analysis (see Bishop and Verleger, 2013). To address this, the work carried out quantitative analysis on the effects of video lecturettes used in a flipped classroom design on the assessment performance of students.

Theoretical contributions of the work are towards testing whether flipped classroom (Bergmann and Sams, 2012) can improve the learning gain (McGrath et al., 2015). The results support those of Alpay and Gulati's (2010) and Hibbard's *et al*., (2015) who found that flipped designs produce better learning outcomes than traditional course designs. Particularly, the study contributes to the literature on the benefits of video lecturettes (e.g., Love *et al*., 2014; Chao *et al*., 2015; Finne, 2018), which are a central element of flipped design. The current study demonstrated the willingness of students to revise their learning through the video lecturettes (Love *et al*., 2014; Khanova *et al*., 2015). More importantly, the results show that this repeated viewing pays off in terms of improved performance in course assessments. Further, the results showed that the wider area of topics students cover through video lecturettes, the better they perform in assessments. Accordingly, the study reached indicative evidence on the learning that can be reached through viewing video lecturettes that are an essential part of modern flipped classroom designs.

An important practical contribution of this study is to provide results that can be applied to develop university teaching in different countries and contexts. The results of this study indicate that flipped classroom improves the student performance in study assessments. Accordingly, it would be tempting to conclude the benefits of the approach in terms of improving student learning, even though further analysis on this is needed. Since flipped classroom does not only increase the productivity of teaching (Finne, 2018), but may also produce improved learning gain (McGrath et al., 2015) more teachers may wish to adopt the teaching strategy. This topic has particular relevance to the Teaching Excellence Framework in the United Kingdom, where learning gain is one of the main contemporary topics. The insights though can impact teaching practice in other countries as well, particularly those where universities increasingly compete over bets students.

This study opens up some fruitful avenues for future research. It would be fascinating to study what kinds of institutional factors facilitate the switch to flipped design. The transformation to flipped classroom may require several capabilities and resources from the teachers and from the institution (e.g. willingness to change, technical skills, technological support, investments to technologies and learning/teaching support).

Accordingly, a direction for future research would be to focus on studying the key factors needed to successfully adopt flipped classroom. In addition, it would be interesting to further investigate students' perceptions on flipped design (Gilboy *et al.*, 2015; Hibbard *et al*., 2015). The results of this study have demonstrated that flipped learning may improve the learning gain of students, but they do not consider students' attitudes towards the flipped design. In several countries, there is an ever growing competition among universities to attract top students, so this might be a central question for many universities considering investments on flipped design.

The hypothetico-deductive approach applied here brings also some limitations, particularly related to the causality. The study did not account for other learning that the students engage in, neither inside nor outside the classroom. Further research is needed to investigate the learning contribution of different elements of education, such as problem-based learning, studying using the course textbook and revising together with classmates. Further, Nielsen (2011) has pointed out the dangers of student centred learning where too much emphasis on student entertainment could get into the way of learning and education. The relationship between entertainment and learning would be worth thorough investigation to understand the degree to which edutainment is actually beneficial for students and the degree to which the local culture may affect this.

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