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Student attitudes towards semi-flipped classroom teaching in a pre-clinical graduate entry to medicine Physiology module

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Abstract

Objectives: Several studies have demonstrated that 'flipped classroom' teaching can significantly enhance student learning. However, there is still relatively little evidence of its successful deployment with regard to the teaching of medical students generally or, more specifically, on accelerated degree programmes such as graduate entry to medicine (GEM). Therefore, we sought to determine the quantitative and qualitative effects of 'semi-flipped classroom' teaching within a respiratory physiology component of a first year GEM module.

Methods: Students were asked to view vodcasts of lecture material prior to attending each of 6 live lectures within the module under study. Class time was then utilised for students to apply their new knowledge either by answering questions or through discussion. Students views of semi-flipped teaching were obtained upon completion of the module via an attitudinal survey. Additionally, student performance in three different exam formats were assessed a control GEM cohort who had completed the same physiology component the year before.

Results: Exam performance did significantly improve relative to the previous GEM 1 cohort in two of the three exam formats used, but this improvement may have been due to other factors. However, survey data revealed that this mode of teaching was not popular with the majority of the students due to a perceived increase in workload upon an already heavy study load.

Conclusions: Semi-flipped teaching as deployed here does not seem ideally suited to this particular cohort of medical students due to the extremely compressed and intensive nature of their course.

Keywords: semi-flipped classroom teaching, vodcasts, active learning, interactive learning environments, teaching/learning strategies

Introduction

With the advent of the digital age, the traditional didactic lecture is rapidly becoming a teaching anachronism, such is its relative ineffectiveness in influencing student learning and understanding (Bligh 1998, Matheson 2008, Mazur 2009, Van der Vleuten and Driessen 2014). In contrast, there is now incontrovertible evidence that active participation of students in their own learning by, for example, applying new knowledge through answering questions, or participation in in-class discussions, produces significant pedagogical benefits to student learning and exam performance far in advance of those achieved with the passive lecture (see inter alia Frederick 1986, Hake 1998, Bransford, Brown et al. 2000, Crouch and Mazur 2001, Beichner and Saul 2003, Stuart, Brown et al. 2004, Knight and Wood 2005, Gannod, Burge et al. 2008, Mazur 2009, Smith, Wood et al. 2009, Deslauriers, Schelew et al. 2011, Kalmey 2013).

One well described model of teaching which encourages active in-class student participation is the 'flipped' or 'inverted' classroom' model (Lage, Platt et al. 2000, Crouch and Mazur 2001, Gannod, Burge et al. 2008, Bergmann and Sams 2012, Tolks, Schafer et al. 2016). This model of teaching encourages a 'blended' approach to learning in which students are provided with resources for foundational knowledge which they are required to study in their own time prior to attending class. Class time is then utilised to analyse and apply this new knowledge. Thus, put in terms of Bloom's revised taxonomy, students carry out lower order cognitive processing (e.g. gaining knowledge and comprehension) outside of, and prior to, lecture/class time, utilising suggested educational materials such as textbooks, audio podcasts, vodcasts, etc.. The students then utilise class time to focus upon higher order processing of their previously acquired knowledge (e.g. application, analysis, synthesis and/or evaluation) supported by the instructor and peers (Krathwohl 2002). This method therefore switches the emphasis of a lecture from being entirely instructor-focussed to it instead being primarily student-focussed, and improves student learning outcomes by facilitating higher order thinking and problem-solving abilities (Bonwell and Eison 1991, Bransford, Brown et al. 2000, Krathwohl 2002, Freeman, O'Connor et al. 2007, Means, Toyama et al. 2009, Moravec, Williams et al. 2010, Means, Toyama et al. 2013).

Because of its proven benefits for both student learning and their engagement with the learning process, there is increasing advocacy for the universal adoption of flipped classroom teaching with medical education (Prober and Heath 2012, Greenberg 2013, Kalmey 2013, Mehta, Hull et al. 2013, Prober and Khan 2013). To that end several studies within this sphere have attested to the positive effects of flipped, or semi-flipped (Gorres-Martens, Segovia et al. 2016), teaching on student learning (Heiman, Uchida et al. 2012, Pierce and Fox 2012, Tune, Sturek et al. 2013, McLaughlin, Roth et al. 2014, Street, Gilliland et al. 2014, Gilboy, Heinerichs et al. 2015, Moraros, Islam et al. 2015, Morgan, McLean et al. 2015, Sharma, Lau et al. 2015, McLean, Attardi et al. 2016). However, the aforementioned studies notwithstanding, research examining the effect of this type of teaching within medical education and allied health disciplines is still in its relative infancy. Indeed, to the best of our knowledge, no studies have yet been conducted to examine the effect of flipped or semi-flipped classroom teaching on accelerated medical degree programs such as graduate entry to medicine (GEM), the subject of the current study.

GEM courses, of which there has been a steady and significant growth throughout Ireland and the UK in recent years, require students to have attained a minimum of a second class honours, grade one (2H1 or equivalent) result in their first undergraduate degree (NFQ level 8) from any discipline, and have attained an appropriate grade in either the Graduate Medical School Admissions Test (GAMSAT) or Medical College Admissions Test (MCAT) before acceptance on to any such programs. The courses themselves run over a period of four, rather than five, years of traditional 'direct-entry' undergraduate medical (DEM) degrees (Duggan, O'Tuathaigh et al. 2014). This is primarily accomplished by compressing the pre-clinical teaching on GEM programs into just over one rather than

two years. Thus, GEM students must learn the same amount of material as their DEM counterparts in effectively half of what is already a brief time period. Therefore, one of the primary considerations when integrating novel teaching strategies such as the flipped or semi-flipped classroom into GEM courses, is that it should be done without imposing further time/study pressures on students (relative to traditional teaching methods).

The current study therefore sought to determine if the efficacy of flipped classroom teaching found within other health professions transferred to a pre-clinical first year GEM medical school curriculum. This was achieved by both empirically determining exam performance following, and student opinions on, the deployment of semi-flipped (Gorres-Martens, Segovia et al. 2016) classroom sessions (instead of traditional didactic lectures) in a compulsory Physiology component of a module taken by a 1st year class of pre-clinical GEM students. Specifically, we sought to answer the following research questions:

1. Did the semi-flipped teaching methodology employed in this study have any significant effect on exam performance?
2. What were the attitudes of the first year GEM students towards semi-flipped classroom teaching as a learning tool?
3. Did attitudes differ across gender or educational background (i.e. whether or not the students' first degree was in a so-called 'biomedical' versus a 'non-biomedical' discipline)?

Methods

Study groups

The study was carried out at University College Cork (UCC) during the spring term of the 2013-2014 academic year. A total of 73 participants (39 females, 34 males) were full time, first year graduate entry to medicine (GEM 1) students studying their second compulsory basic science module (GM1002 – Fundamentals of Medicine). General demographic information on the study groups is shown in Table 1.

Table 1

Self-Reported Demographic Data of GEM 1 at University College Cork Medical School Who Responded to the Survey Conducted in the Spring Term of 2013.

Demographics	Number of survey respondents 2013-2014	Number in GEM 1 2012-2013*
Gender		
Male	28 (average age 25.3±0.6, range 22 – 34)	38 (average age 25.6±0.5, range 21-36)
Female	37 (average age 24.1±0.3, range 22 – 28)	30 (average age 24.1±0.5, range 21-29)
Nationality		
EU	35 (14 ♂, 21 ♀, 4UA)	36 (18 ♂, 18 ♀)
Non-EU	26 (13 ♂, 13 ♀)	32 (20 ♂, 12 ♀)
Undergraduate degree		
Biomedical	41 (20 ♂, 21 ♀), 2UA	N/A
Non-biomedical	20 (7 ♂, 13 ♀)	N/A

UA=unanswered, N/A= information not available

* Indicates numbers obtained from UCC student records rather than survey data

From data gathered in the attitudinal survey, the mean age of the class was 25.0 ± 0.3 years (n=56, range = 22-34, mean ± S.E.M.). Within the 13-14 class there was a small but significant difference in age between the males and females (25.3 ± 0.6, n=28 vs 24.1 ± 0.3, n=35 respectively, $P < 0.05$).

For quantitative purposes, the 2013-2014 GEM 1 class's performance on specific questions contained within, continuous assessment, end of module and end of year exams was compared with the performance *against the same questions* of the preceding year's (2012-2013) GEM 1 class (who had had no exposure to the vodcasts and could therefore act as a control group). For the sake of comparison, the mean age of the 2012-2013 GEM 1 class was 24.9 ± 0.3 years (n=68, range 21-36) and there was also a small but significant difference in age between the males and females (25.6 ± 0.5, n = 38 vs 24.1 ± 0.5, n= 30, respectively, $P < 0.05$).

Creating and publishing vodcasts

The Physiology vodcasts that students were expected to view prior to attending classes were recorded (in advance of

scheduled live lectures) using Panopto lecture capture software which allows a) the user to record presentations in a combined audio and visual package with attendant cursor moves, and b) the viewer to pause, move forward and backward through the content, skip to specific slides, or listen to the presentation at accelerated rates up to twice normal speed. Vodcast files were made available to the students on UCC's virtual learning environment, Blackboard (supplied by Blackboard Inc.), at least two weeks prior to each scheduled lecture slot, and remained available for download until the end of the academic year. All of the students involved in the study were regularly made aware of the existence of the vodcasts by one of the authors (M.G.R.).

Additionally, for both the 12-13 and 13-14 year groups, the Microsoft PowerPoint (MPP) presentations used to prepare each vodcast and full sets of learning outcomes accompanying each lecture (which were identical for both years), were also made available on Blackboard for download.

Vodcast content

The 6 vodcasts and lectures utilised in the study (out of a total of 19 Physiology lectures) were all recorded and delivered by the same lecturer over the course of 5 weeks in the 14 week teaching period of module GM1002. The other 13 lectures in the module were delivered in traditional didactic format by one other lecturer and were not accompanied by vodcasts of any description. The mean duration of each recorded vodcast per lecture slot was 56.6 ± 6 minutes, range = 35.4 – 72.1 mins).

Students were advised of the educational rationale for using the vodcasts and further instructed that viewing of the vodcasts prior to each scheduled lecture was a pre-requisite in order for them to be able to answer the in-class questions during the timetabled lecture slot.

GM1002 lecture styles

The timetabled Physiology lectures accompanying each vodcast for the 13-14 GEM 1 class in module GM1002 were primarily structured around material contained within the vodcasts. However, scheduled lecture time was used to briefly summarise sections of material contained within the vodcasts and to then ask the class several single best answer (SBA) format questions (whereby questions are formulated around a question stem and the student has to select the single best answer from a list of five options) about that same material to gauge their understanding of its content.

The class responded to questions using individual audience response units or 'clickers' which worked in conjunction with specialist software (Option Power®). This allowed the instructor to generate question slides, integrated into normal MPP presentations, which allowed students to answer questions anonymously and also provided an instantaneous graphical breakdown of how each question had been answered (on the question slide itself). The instructor could then provide feedback on each conceptual question based upon how well the question had been answered [12].

The same six GM1002 respiratory physiology lectures delivered to the 2013-2013 GEM 1 class the previous year were all delivered as traditional didactic lectures with minimal student participation, as were the other lectures in the Physiology component of GM1002 which were delivered by the one other Physiology lecturer on this module.

Quantitative assessment of efficacy of vodcast usage using single best answer (SBA) questions

In order to quantitatively assess the efficacy of vodcast usage in the 13-14 GEM 1 year group against the control 12-13 GEM 1 year group, their performance in the Physiology component of three distinct examination scenarios,

continuous assessment (CA), end of module (EOM) and end of year exams (EOY), was assessed. The primary mode of assessment in all three types of examination was also SBA questions.

Both the 12-13 and 13-14 GEM 1 students sat six Physiology continuous assessment (CA) exercises at regular intervals throughout the GM1002 module. Each CA test was conducted electronically using a secure browser in the same proctored setting each time, with the class as a whole. Access to the CAs was restricted only to members of the GEM 1 classes and was secured by specific student identification number.

Each CA in GM1002 contained approximately 20 questions of which roughly one quarter were in SBA format and *related directly to the material covered by the 6 respiratory physiology vodcasts*. This yielded a total of 31 SBA questions which had been answered by both year groups and could therefore be used for comparing performance between the two year groups.

For the GM1002 end of module (EOM) exam, which was conducted one week after the completion of the GM1001 lectures, the number of valid Physiology SBA questions which could be used for comparative analysis fell to seven. For the GM1001 end of year (EOY) exam, which took place approximately 2.5 months after completion of the GM1002 module, the number of valid Physiology SBA questions which could be used for comparative analysis was 12.

Therefore, due to the fact that all of these questions were included in both CA exercises as well as EOM and EOY exams, it was possible to monitor performance both whilst the course was being taught as well as *after* all of the material had been delivered.

Statistical analyses

Statistical analyses were performed using Microsoft Excel. For analysis of success rates of the 12-13 versus 13-14 year groups against the questions utilised in the GM1002 CA, EOM and EOY examinations a paired Student's *t*-test was utilised with all data expressed as mean \pm standard error of the mean (S.E.M.). For data which were unpaired (*e.g.* comparison of MCAT and GAMSAT scores, student ages between the two year groups, *etc.*), an unpaired Student's *t*-test (assuming equal variance) was utilised. Graphs of data were prepared using GraphPad Prism 5 (GraphPad Software Inc., San Diego, CA, USA).

Attitudinal questionnaire

Students were asked to complete a survey at the end of the 2013-2014 GM1002 module (see appendix 1 for full survey) about their perceptions of both the flipped classroom teaching as employed in the current study and the accompanying vodcasts in the month following the delivery of the final study lecture for which the vodcasts had been prepared.

The survey initially requested the age, sex, nationality (EU *versus* non-EU) and educational background (biomedical or non-biomedical) of the students. Thereafter the survey results discussed herein focussed upon the students use, and perceptions, of the vodcasts. For this, the survey took the form of five, 5 – point Likert scale questions (strongly agree, agree, neutral, disagree, strongly disagree), two semantic differential item and two open-ended essay-type questions, which enabled participants to make comments about the use of the Physiology vodcasts in the GM1002 module.

Survey data were manipulated to provide a read out of the class's overall percentage responses to each question/statement in the survey. However, survey data were analysed further to determine if there were any major

differences in the types of responses to the survey questions between,

- a. all males and all females
- b. all students from a self-declared biological background versus all students from a self-declared non-biological background
- c. male students from a self-declared biological background versus male students from a self-declared non-biological background
- d. female students from a self-declared biological background versus female students from a self-declared non-biological background.

When the Likert options for each question were condensed by combining the 'strongly agree' with the 'agree' option, and 'strongly disagree' with the 'disagree' option, broadly speaking, there were no major differences in the types of responses received from male and female students as a whole nor between male and female responses in the biological versus non-biological cohorts. However, there were some notable differences when the responses of the non-biologists were compared to those of the biologists to certain questions/statements. It is for this reason that only the responses of these subgroups are displayed in the relevant figures and discussed further.

Results

12-13 vs 13-14 MCAT & GAMSAT scores

There was no statistically significant difference in the overall relative intellectual abilities of the 12-13 and 13-14 GEM 1 classes as determined by either their MCAT (12-13 = 31.5 ± 0.4 , $n=37$ vs 13-14 = 30.7 ± 0.4 , $n=39$) or GAMSAT scores (12-13 = 58.4 ± 0.6 , $n=37$ vs 13-14 = 58.3 ± 0.5 , $n = 39$), or between males and females either within each group or between each year group.

Effect of flipped classroom teaching on exam performance

As we wished to determine whether or not the use of vodcasts improved student understanding of taught material, one way to measure this was to determine if overall exam performance improved relative to a control group. This was determined by examining performance in three different exam scenarios; continuous assessment (CA) examinations, which ran throughout the module, an end of module (EOM) exam, which took place one week after teaching on the GM1002 module had ended was also examined and in an end of year (EOY exam), which took place 2.5 months after the end of the GM1002 module.

Figure 1A shows that although overall student performance against the 31 questions used for comparative analysis in the CA exams did improve slightly for the 13-14 year group relative to that of the 12-13 year group ($63.5 \pm 4.5\%$ in 12-13 vs $68.4 \pm 4.4\%$ in 13-14, $n=31$) this increase was not significant ($P=0.1$, Student's paired t -test).

This result was in contrast to that obtained for the GM1002 EOM where we found that there was a significant improvement in performance by the 13-14 GEM 1 class relative to the 12-13 class in the 7 identical questions answered by them ($55.4 \pm 3.9\%$ in 12-13 vs $60.3 \pm 4.4\%$ in 13-14, $n=7$, $P<0.05$, Student's paired t -test; figure 1B). It was also notable that when the performance of the 13-14 GEM 1 class relative to that of the 12-13 GEM 1 class in 17 questions relating specifically to the material taught by the one other Physiology lecturer on GM1002, there was a statistically significant *reduction* in the percentage of correct answers ($67.6 \pm 2.7\%$ in 12-13 vs $62.1 \pm 2.7\%$ in 13-14, $n=17$, $P=0.013$, Student's paired t -test; *data not shown*).

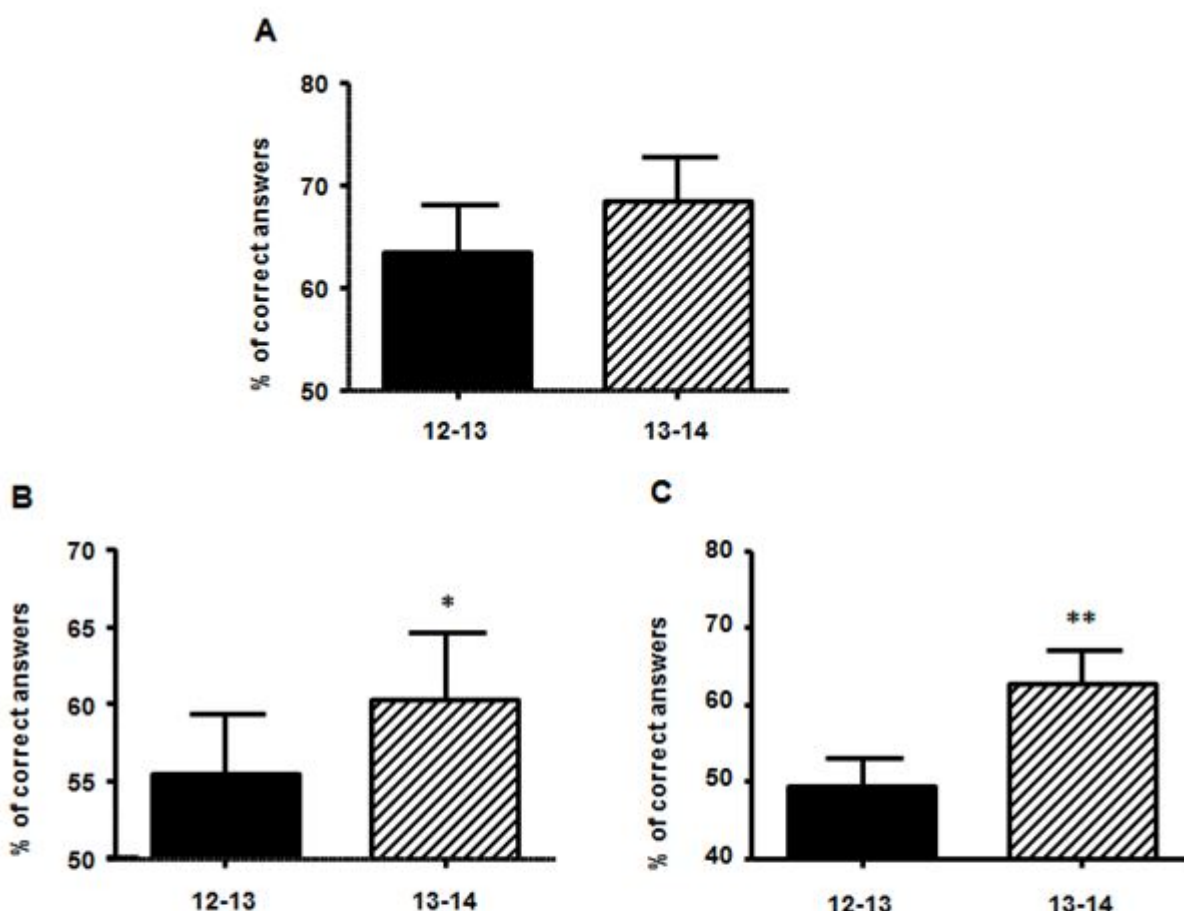


Figure 1: Comparison of performance between 12-13 and 13-14 GEMI students in questions in GM1002 CA, EOM and EOY exams. Histograms illustrating the averaged percentage of correct responses recorded in GM1002 exams by GEMI 12-13 (black bar) and 13-14 (hatched bar) students to 31 identical questions posed in 3 CA exercises spread throughout module GM1002CA exams (A), 7 identical questions posed in the EOM exam (B) and 12 identical questions posed in the EOY exam. * and ** indicates $P < 0.05$ and $P < 0.01$ respectively.

A statistically significant improvement in exam results of the 13-14 GEM 1 year versus the 12-13 year group was also evident when we investigated performance against 12 identical questions in the GM1002 EOY exam ($49.5 \pm 3.7\%$ in 12-13 vs $62.8 \pm 4.5\%$ in 13-14, $P = 0.002$; paired Student's *t*-test, $n = 12$; figure 1C). Again, it was possible to control for the combined effect of the vodcasts and 'flipping the classroom' on student learning by examining performance in questions relating to material taught solely by the one other GM1002 lecturer for both the 12-13 and 13-14 classes (which were not accompanied by vodcasts of that material). Analysis of these data, which comprised 14 questions in total, demonstrated that there was no statistically significant change in performance between the two

years ($70.9 \pm 5.7\%$ in 12-13 vs $71.9 \pm 5.6\%$, $P = 0.4$, $n = 14$, paired Student's t -test; *data not shown*).

Vodcast viewing statistics

When students were asked, '**Of the 6 that have been made, how many of the GM1002 Physiology vodcasts did you view/listen to prior to attending the relevant lecture?**' the results revealed that although over three quarters (77%) of the respondents stated that they had viewed at least three of the vodcasts before the relevant lectures, only 12.5% claimed to have viewed all six. It is also notable that nearly one quarter of the class (23%) did not view any of the vodcasts prior to attending each lecture. Interestingly, the self-reported data also indicated that the students from non-biomedical backgrounds, on average, viewed more of the vodcasts prior to lectures than the biomedical background students (3 ± 0.5 , $n=15$ vs 2.1 ± 0.3 , $n=40$, respectively), although this difference was not statistically significant ($P=0.06$).

Attitudinal survey results

Although the effect of flipping the classroom on exam performance was an important aim of the current study we were also very interested in determining students' views on the change in lecture format. To that end, option seven of the survey asked for student responses to the statement, '**I liked the format of Dr Rae's lectures in GM1002, e.g. more time spent answering / reviewing questions and going over more difficult concepts, rather than delivering a 'conventional', non-participatory, lecture**'.

The results shown in figure 2A for the class overall indicate that the majority of the class (59% vs 36%) did not favour the semi-flipped classroom model of teaching that had been introduced for the 6 lectures analysed here. However, if one compares the responses from students with biomedical backgrounds to those with non-biomedical backgrounds a more nuanced picture emerges as shown in figures 2B and C. Specifically, it is clear that the vast majority of the biomedical students either strongly disagreed or disagreed with the statement (65% vs 23% who did not like the newer format), whereas the majority of the non-biomedical students (67%) who strongly agreed or agreed with it, and presumably did therefore favour the revised format of lectures.

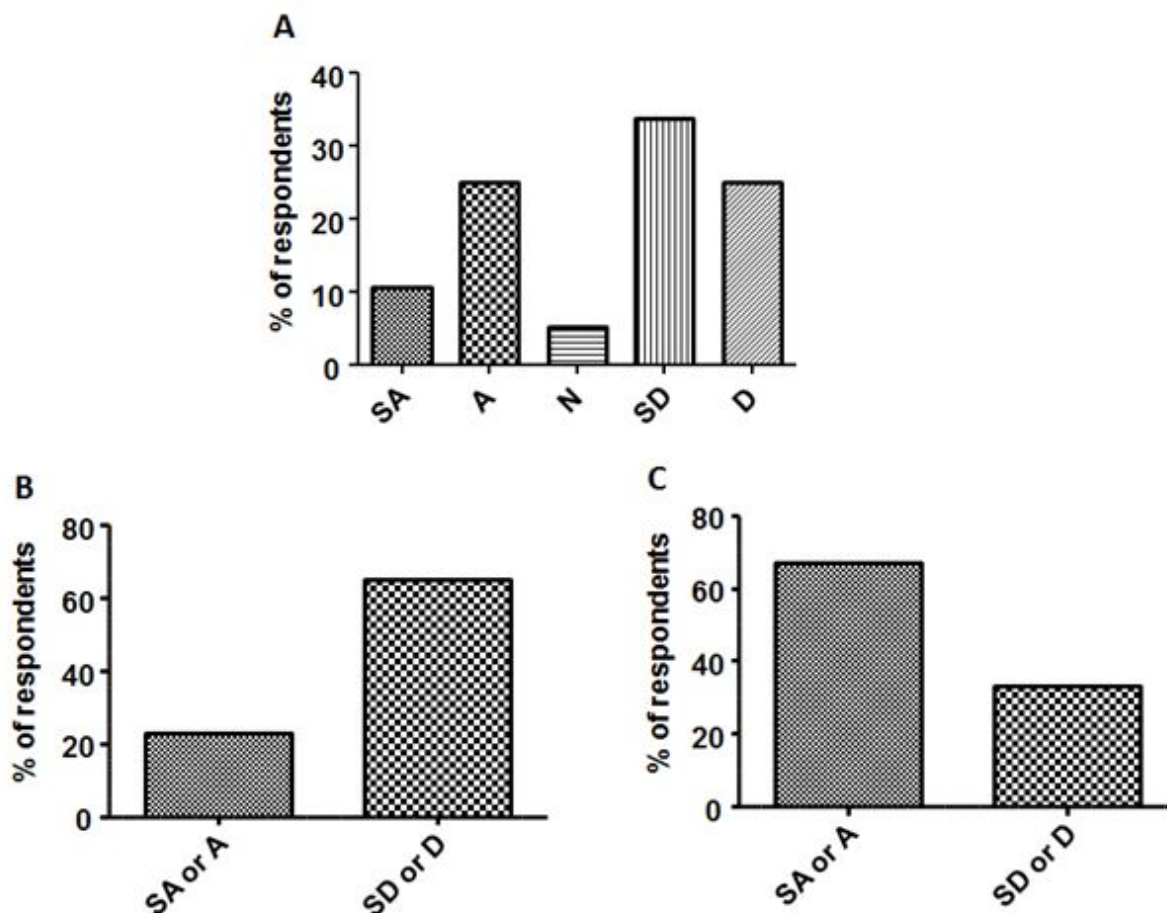


Figure 2: Histograms illustrating responses to the statement, 'I liked the format of Dr Rae's lectures in GM1002, e.g. more time spent answering / reviewing questions and going over more difficult concepts, rather than delivering a 'conventional', non-participatory, lecture'. Overall class response to the question (A), responses of those with a biomedical background prior to entering the UCC GEM course (B), and responses of those with a non-biomedical background (C) prior to entering the UCC GEM course. SA = strongly agree, A = agree, N = neither agree nor disagree, D = disagree, SD = strongly disagree.

Next, survey option eight sought responses to the statement, '**I felt that the format of Dr Rae's lectures in GM1002 (e.g. being asked to review material (lecture slides and/or vodcasts) beforehand and answering questions during lecture time) facilitated a greater understanding of the relevant material**', with results shown in figure 3. Overall, most of the students indicated that they did not feel reviewing lecture material before lectures helped their understanding of the material during the lecture itself (43% disagreed or strongly disagreed vs 32% agreed or strongly agreed, with 25% of respondents neutral). However, when the respondents were separated into biomedical *versus* non-biomedical categories, the non-biomedical students were once again much more positive about the pedagogical benefits of previewing the vodcasts (60% SA or A, 7% SD or D) compared to the biomedical students (18% SA or A, 55% SD or D) (see figures 3B and C).

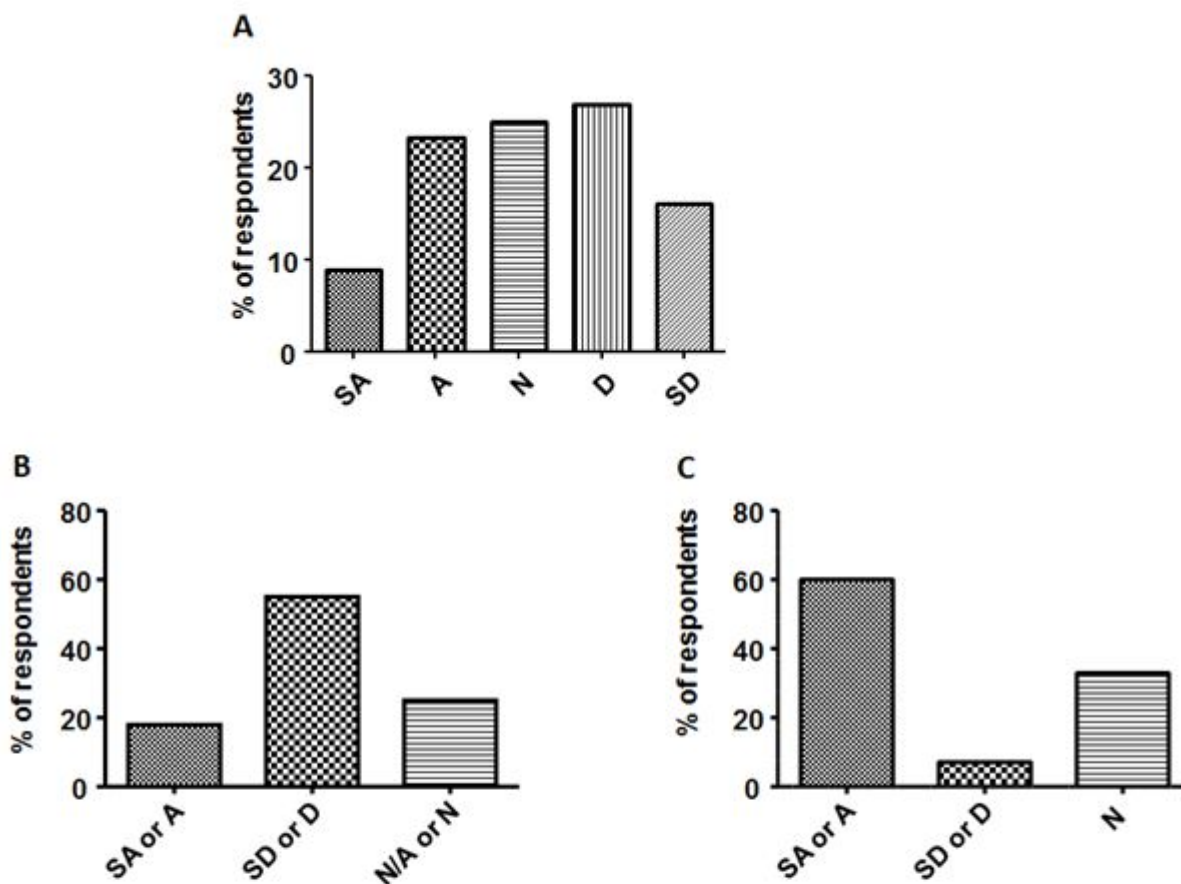


Figure 3: Histograms illustrating responses to the statement, 'I felt that the format of Dr Rae's lectures in GM1002 (e.g. being asked to review material (lecture slides and/or vodcasts) beforehand and answering questions during lecture time) facilitated a greater understanding of the relevant material'. Overall class response to the question (A), responses of those with a biomedical background prior to entering the UCC GEM course (B), and responses of those with a non-biomedical background (C) prior to entering the UCC GEM course. SA = strongly agree, A = agree, N = neither agree nor disagree, D = disagree, SD = strongly disagree, N/A = not applicable.

However, responses to the statement, 'Of the GM1002 Physiology vodcasts that I have viewed/listened to prior to the relevant lecture, they have helped me to better understand the material and answer the questions presented during the lecture' (survey option eleven) revealed, somewhat confusingly given the results shown in figure 3A, that 57% of all respondents this time strongly agreed or agreed with the statement (figure 4). When the students' responses were again divided into either biomedical or non-biomedical categories, there was once more a striking disparity between the responses, with 73% of the non-biomedical students strongly agreeing or agreeing with the statement (see figure 4C), as opposed to only 48% (with 38% neither agreeing or disagreeing) of the biomedical students (see figure 4B).

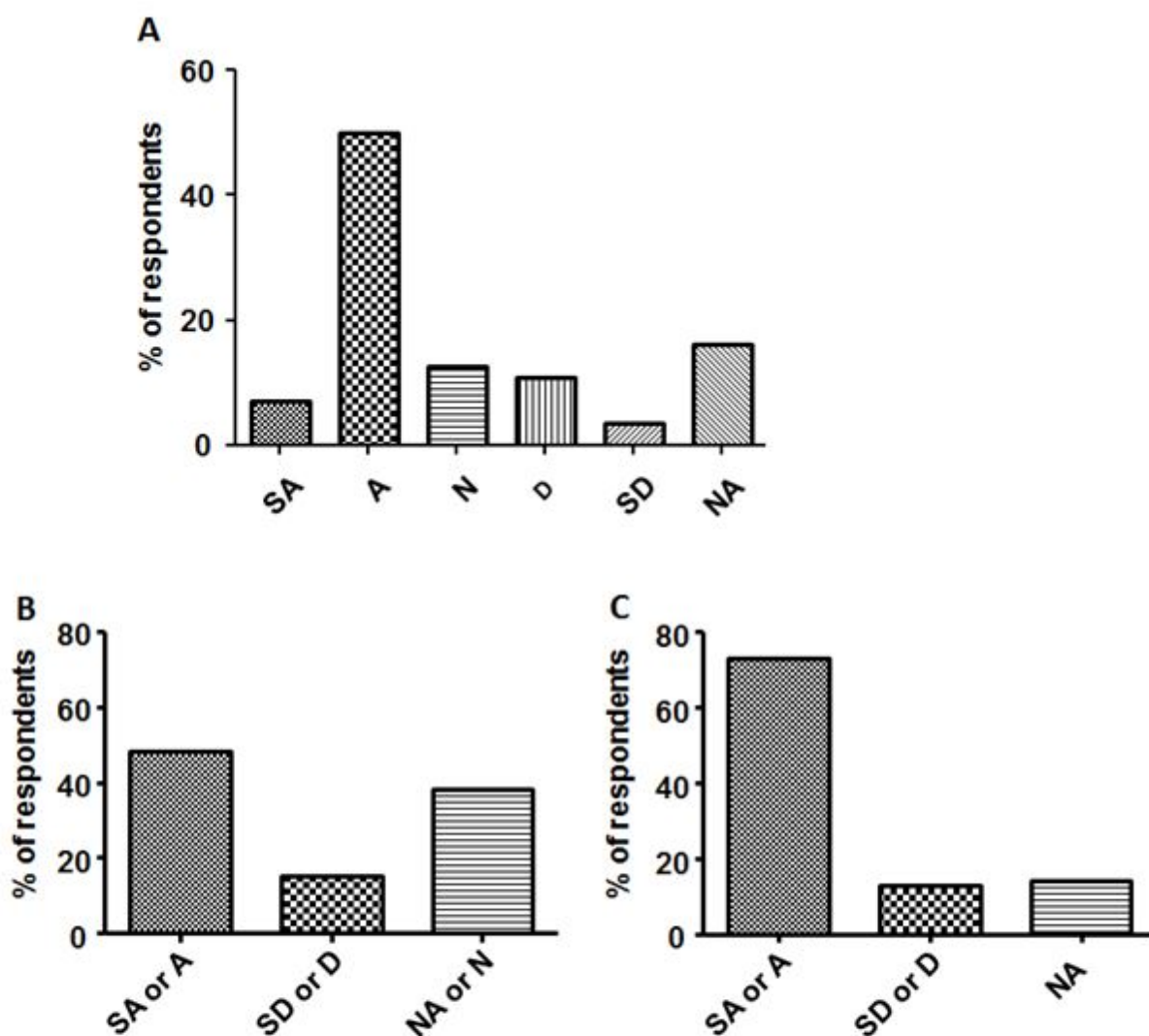


Figure 4: Histograms illustrating responses to the statement 'Of the GMI1002 Physiology vodcasts that I have viewed/listened to prior to the relevant lecture, they have helped me to better understand the material'. Overall class response to the question (A), responses of those with a biomedical background prior to entering the UCC GEM course (B) responses of those with a non-biomedical background (C), prior to entering the UCC GEM course. SA = strongly agree, A = agree, N = neither agree nor disagree, D = disagree, SD = strongly disagree, NA =not applicable.

Continuing with this theme, students were next specifically asked if they preferred the 'old style' didactic lectures ('I would prefer it if Dr Rae stuck to a more conventional lecture delivery style (rather than the style employed in GM1002) in which no prior knowledge is assumed, even if it means rushing through key concepts' (survey option nine)). Given the results shown in figure 3, it was not too surprising that the majority of the class (48%) strongly agreed or agreed with the statement, with only 18% disagreeing with the statement. However, it was interesting that a majority of the students with a non-biomedical background also felt the same way (53% vs 33%

that disagreed) in spite of the majority previously indicating that they thought that the prior viewing of vodcasts and the semi-flipped classroom teaching facilitated a greater understanding of the material for them.

However, in probing this question further with the statement, **'I would prefer NOT to have to answer questions at all during lectures'** (survey option ten), it did not seem as though the students were against being asked questions *per se* as indicated in figure 5. Thus, irrespective of whether one views the class results as a whole or broken down into biomedical or non-biomedical students, all groups mostly *disagreed* with this suggestion (64% overall, 60% biomedical students and 80% non-biomedical students; figure 5).

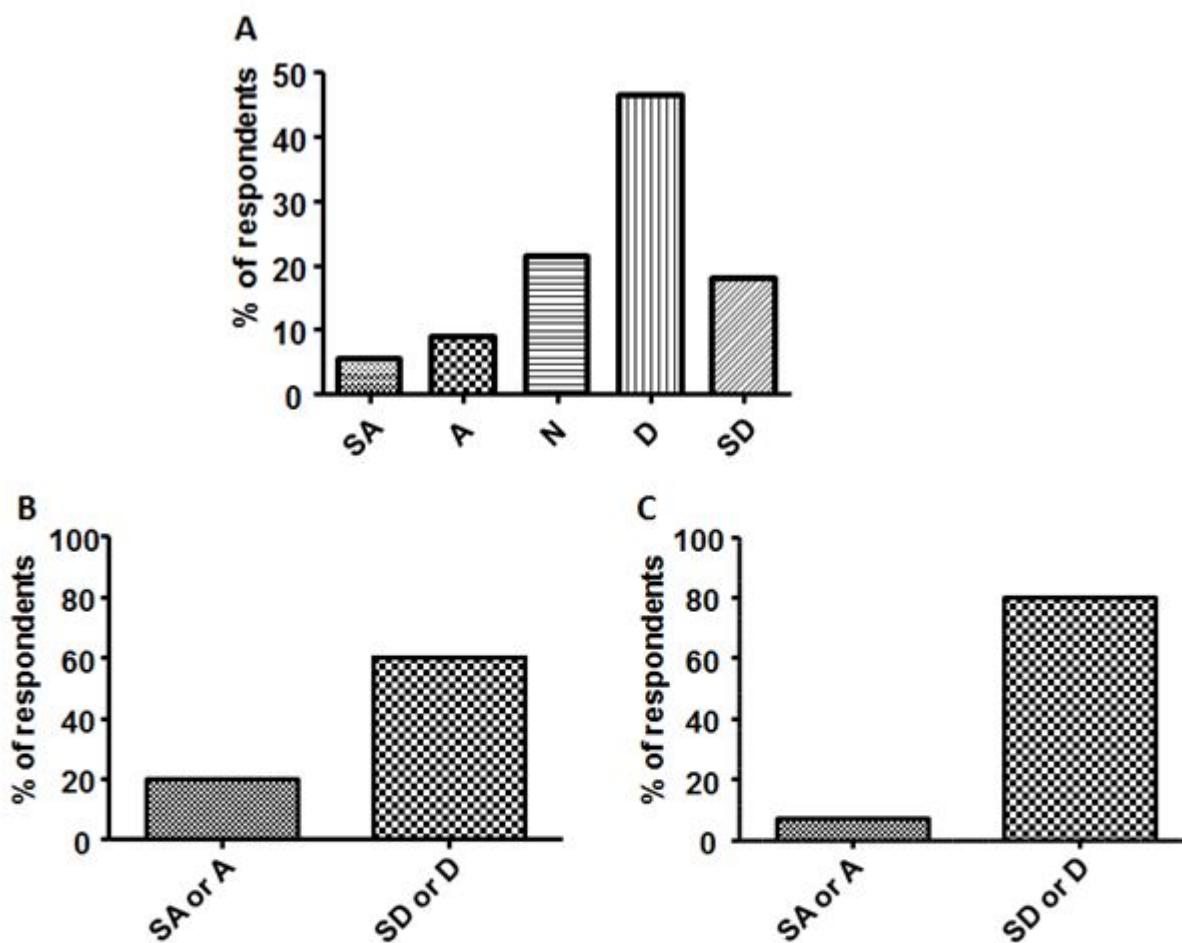


Figure 5: Histograms illustrating responses to the statement, 'I would prefer NOT to have to answer questions at all during lectures'. Overall class response to the question (A), responses of those with a biomedical background prior to entering the UCC GEM course (B), and responses of those with a non-biomedical background (C) prior to entering the UCC GEM course. SA = strongly agree, A = agree, N = neither agree nor disagree, D = disagree, SD = strongly disagree.

Discussion

The current study sought to determine, qualitatively and quantitatively, the impact of semi-flipped classroom teaching upon students in a pre-clinical GEM Physiology module.

Quantitatively, and in line with previous work in this area (*e.g.* see *inter alia* Freeman, O'Connor et al. 2007, Means, Toyama et al. 2009, Moravec, Williams et al. 2010, Pierce and Fox 2012, Tune, Sturek et al. 2013, Street, Gilliland et al. 2014, Gorres-Martens, Segovia et al. 2016) the semi-flipped classroom approach did seem to have an overall positive effect on exam performance of the test group of students in two out of the three formats of exams conducted for this particular investigation, when compared to control group of GEM 1 students. However, that said, we were surprised that there was no significant improvement in students' CA exam performance. Indeed, we anticipated that if we were to see an improvement in student exam grades by flipping the classroom, then it would likely be manifested most clearly in these CA exams as they were conducted in relative temporal contiguity with the lectures. Quite why this did not happen is not exactly clear but one of the most likely causes may have been the relatively low level of student engagement with the semi-flipped classroom process in this study. Thus, if only 15% of students viewed all of the vodcasts prior to each face-to-face session) in which their knowledge was applied and/or tested then it is logical to conclude that the 85% of students who did not prepare for at least one of the semi-flipped sessions, would receive no tangible benefit to their understanding of the material analysed in those sessions.

Although we did see a statistically significant improvement in EOM and EOY exam grades within the 2013-2014 GEM 1 class relative to the 2012-2013 class, which could not be accounted for in terms of the relative intellectual abilities of the two cohorts, this may have been due at least in part to the semi-flipped classroom exercises, we cannot discount the strong possibility that the improvement may also have been due, wholly or in part, to the access the students had to the lecture vodcasts throughout the module. Indeed, anecdotal evidence suggested that the vodcasts served a dual purpose for the students for these particular exams: initially providing a first pass exposure to lecture material prior to its delivery as was intended, but also acting as an invaluable revision resource for the EOY examination several weeks after the material had initially been taught.

Qualitative data obtained from the survey drew a mixed, relatively nuanced picture of students' perceptions of the semi-flipped classroom exercise conducted for this study. For example, overall, the majority of the respondents felt that semi-flipped teaching did *not* improve their understanding of the material (in spite of the fact that the majority of students who previewed vodcasts prior to face-to-face sessions with the author, felt that they improved their understanding of material in the session), nor did they favour the use of this style of teaching relative to normal didactic lectures. However, if nearly half of the class only prepared for a maximum of two lectures, then one would have to suggest that this viewpoint was expressed without most students having engaged with the process. Nonetheless, it is notable that there was also a clear division within the class along educational background lines in this regard as the majority of those with non-biomedical training/degrees responded very positively to the semi-flipped classroom model, whereas those from a biomedical background expressed the diametrically opposite view. Interestingly however, of those non-biomedical students who previously expressed a positive sentiment towards 'flipped' teaching, the majority still indicated that they would have preferred traditional didactic teaching in which 'no prior knowledge is assumed, even if it means rushing through key concepts'.

It is tempting to deduce from these findings that some students simply, a) did not want to prepare for lectures and, b) were quite happy to forego active learning within the classroom and stick with traditional passive didactic teaching, as has been noted in several other studies involving undergraduate medical students (Street, Gilliland et al. 2014, White, Bradley et al. 2014, White, McCollum et al. 2015). However, this suggestion is somewhat contradicted by the

finding that the majority of the students, both biomedical and non-biomedical, indicated that they *did* want to be asked questions during lectures. Although this point was not interrogated further in the present study, it may be that although the students did not wish to prepare for, and answer questions on, the material contained within the 'current' lecture, they may have been happy to answer questions on preceding lectures, once they had had time to digest and revise this information. Herein we think lies the central conundrum facing most lecturers wishing to incorporate this style of teaching into their own curricula. Thus, with flipped or semi-flipped teaching, students often find it difficult to get past the idea that they are being asked, effectively, to revise the same material twice, *e.g.*

"Conventional lecture style works. I'm slightly annoyed that we have to spend 2 hours (vodcast +lecture) to get 1 hour worth of material."

"Considering the large amount of content in this course, and the amount of class hours already allotted to physiology in the timetable, students DO NOT [student's emphasis] have enough time to watch a [vodcast] before the scheduled lecture and then go on to attend the lecture on the same material"

"I feel that it is unfair and unhelpful that everyone is expected to have reviewed an hour long [vodcast] prior to each lecture and to not fully cover the lecture material during lecture time"

Although this student perception has not been found for all flipped and/or semi-flipped classroom studies involving medical students (*e.g.* see Lage, Platt et al. 2000), we, and others (McLaughlin, Roth et al. 2014, Khanova, Roth et al. 2015), have found that it persists with some of our students in spite of clearly explaining the rationale, pedagogy and proven benefits of flipped and/or semi-flipped teaching on student learning. Similarly, explaining that engaging higher order cognitive processing by interrogating their knowledge of a topic (and receiving feedback), during the relatively limited scheduled teaching time, instead of simply gaining 'first pass' exposure to a topic, a) represents a much more efficient use of time a class has with lecturers and b) is likely to yield tangible learning outcomes (Crouch & Mazur, 2001; Gannod et al., 2008) tends to be drowned out by students' complaints about not having enough time to view the preparatory material. Indeed, the perception of having insufficient time to view the preparatory material was a recurrent theme in this study with nearly half (48.8%, 20 students) of those who responded to the survey option making this specific point *e.g.*,

"While I can see the benefit in the vodcasts, it's not always possible to view them prior to the lectures as they are very time consuming. Due to the lack of physiology in my previous education, in order to truly follow the [vodcast], I have to look at other material outside them in order to grasp the concepts, this can take up an entire evening to the detriment of other studies required in the module."

"While I appreciate the availability of the vodcasts and the theory behind them, I find that in the context of the entire GM1002 module (with the time commitments I have to learn the other subjects in the module) they are a little bit too time-consuming to be of optimal benefit for me"

"While reviewing the podcasts / lecture slides prior to the lecture would, without a doubt, improve understanding of the relevant material DURING [student's emphasis] the lecture, it comes down to a lack of time that prevents this from being feasible most of the time"

The comments above also suggest that whilst students may well understand and appreciate the pedagogical principles

underlying active learning (such as preparing in advance for flipped classes) on an intellectual level, behaviourally many will "opt out of or complain about participating in higher order classroom activities" if it becomes too inconvenient or challenging to manage" as previously discussed by White *et al.*, (2014).

However, there must also be some acceptance by educators that one cannot simply 'impose' what is likely to be in most cases a completely novel method of teaching and learning upon students without expecting at least some resistance due, at the very least, to a substantial change in their previously held perceptions of the 'normal' student:educator *status quo*. This is particularly true in graduate entry undergraduate programs such as this where the vast majority of students entering the course have completed degrees in which traditional didactic teaching was the norm and to which the students have completely adapted their learning to, its inherent flaws notwithstanding (Street, Gilliland et al. 2014). Viewed from this perspective, it may be that students simply require more time to adapt 'flipped' teaching, as demonstrated recently by Gorres-Martens *et al.* (2016) rather than the relatively short-lived and isolated exposure to it that they received in the current study.

Limitations of the current study

One of the most obvious limitations of the current study is that it was conducted in a single school, with a relatively limited number of students, on a relatively small component of the Physiology section of the overall GM1001 module. Therefore, one's ability to generalize its findings to other accelerated medical degree programs is limited. However, as discussed in the Introduction, given the relative paucity of published data pertaining to these types of undergraduate courses in general, all studies in this area, limited or otherwise should still be welcomed.

Limitations relating to design of the study were also identified. Firstly, we did not block student access to the vodcasts once each lecture had been delivered which prevented us from making definitive conclusions specifically as to how the previewing of vodcasts as preparatory material affected *post-hoc* exam performance. However, rather than being an oversight of the study, we consciously made this decision simply because we felt that it would have been unethical to prevent students from accessing the vodcasts after the study period, particularly given the substantial unsolicited feedback we received about how useful students had found them for revision during a previous study (Rae and McCarthy 2017 (*in press*)). Secondly, it is clear from the student feedback that many students felt that the duration of the assigned 'homework' vodcasts were far too long which resulted in them simply disengaging from the whole process, a situation which may have been circumvented with the use of briefer (*e.g.* 10-20 minutes), more focussed and engaging (*i.e.* not lecture content) online material (Street, Gilliland et al. 2014, Sharma, Lau et al. 2015, Gorres-Martens, Segovia et al. 2016).

A third limitation of the study was that, because of the way our institution's learning management system was configured at the time of the study, we were unable to independently verify if the self-reported student vodcast viewing statistics were accurate. However, even if this information was available we would still be unable to accurately determine exactly how many students actually watched the vodcasts all the way through as opposed to simply downloading the files (which is what the system now logs). Therefore, we are unable to draw any firm conclusions about student vodcast viewing habits and how they correlated with exam performance.

Future studies

Any future studies in this area would seek to address at least some of the limitations of the current study listed above. For example, in order to encourage wider student engagement with the pre-'lecture' study material, the material will be gauged in such a way that out-of-class time commitment to its study is the same as it would be for traditional lectures (*e.g.* online material would be limited to 10-15 minutes; Street, Gilliland et al. 2014). Further, the study material itself would be delivered in a variety of formats, not only to cater for the needs of students with

different learning styles, but also to maintain the interest of the class (Lage, Platt et al. 2000, Street, Gilliland et al. 2014, Sharma, Lau et al. 2015, Gorres-Martens, Segovia et al. 2016). The use of pre- and/or post-vodcast quizzes could also be utilised to encourage students to view the assigned material (Sharma, Lau et al. 2015, Gorres-Martens, Segovia et al. 2016). Finally, a 'scrambled' teaching model, rather than flipping all lectures, may be a more preferable approach in future, particularly for this cohort of students. As the name suggests, the 'scrambled' approach uses a variety of teaching techniques (*i.e.* a combination, in different learning environments, of flipped lectures, team based learning, traditional didactic lectures, problem-based learning) in order that students do not become bored with one particular type of methodology whilst still largely encouraging active student participation in their own learning (Gorres-Martens, Segovia et al. 2016).

Conclusions

Due to its demonstrable benefits upon student learning, the implementation of flipped classroom teaching is currently being advocated by several influential sources (Prober and Heath 2012, Greenberg 2013, Kalmey 2013, Mehta, Hull et al. 2013, Prober and Khan 2013). However, in spite of this, we feel that it has yet to be clearly established that the introduction of flipped classroom teaching wholesale into medical programs would be appropriate for all students under all circumstances.

To this end, our study has revealed that in spite of the aforementioned benefits of flipped teaching on student learning and understanding in medicine, we, in line with several other studies (Tune, Sturek et al. 2013, Street, Gilliland et al. 2014, White, Bradley et al. 2014, Khanova, Roth et al. 2015, White, McCollum et al. 2015), found that its introduction into a Physiology component of a first year GEM programme was less than universally popular with the students involved in the study. Previous work within the medical sphere has suggested that where dissatisfaction with this style of teaching does arise, it can be a result of several factors such as pre-class learning not aligning with in-class teaching, poor quality of pre-class learning materials, unsuitable formats of in-class learning, a certain percentage of students which simply prefers the standard didactic lecture and, in accordance with the present study, a perceived increase in workload (Pierce and Fox 2012, Street, Gilliland et al. 2014, Gilboy, Heinerichs et al. 2015, White, McCollum et al. 2015) which leads many to disengage with the entire exercise. Indeed, striking a balance between in – class and out-of-class work such that students do not feel that they are being overworked relative to traditional didactic lectures is one of the main impediments to a more widespread implementation of flipped classroom teaching within medical courses generally, and for GEM courses in particular. As we have found, without striking such a balance students are likely to reject any pedagogical arguments or evidence in favour of such methodology if the amount of effort required becomes unwieldy. Further, we propose that this balancing act would become almost unmanageable on pre-clinical GEM courses if multiple contributors all adopted flipped teaching without enormously careful consideration of the additional homework burdens this would likely impose upon students, particularly since material cannot simply be cut from the pre-clinical medical curriculum 'in order to create extra time for more in depth analysis and application' (Street, Gilliland et al. 2014).

Last, but certainly by no means least, faculty wishing to implement flipped classroom teaching within their curricula need to be fully cognisant of the considerable commitment, time, effort, dedication, experience and no little skill that is required both to initially develop this kind of program but also to subsequently fully support such a program (Street, Gilliland et al. 2014).

Therefore, to conclude, although flipped teaching can provide undoubted benefits to student understanding and learning, our findings suggest that one must take a carefully measured approach to its implementation, taking into account the particular requirements and existing learning load of the class being taught. In the case of students on

accelerated professional courses such as GEM for example, who are taught four to five subjects simultaneously in a very compressed timetable, the scheduling required to accommodate this teaching leaves very little time for self-directed learning required for flipped classroom teaching. This, in turn, may ultimately result in students disengaging from the process and, as a result, end up performing more poorly than they might have done attending traditional didactic lectures.

Take Home Messages

Notes On Contributors

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Appendices

GM1002 Physiology Vodcast Survey

1. Essay: **Are you male or female?**
2. Essay: **What age are you?**
3. Essay: **Did you enter UCC from a non-EU or EU country?**
4. Essay: **Would you consider your educational background to be biomedical or non-biomedical?**

5. Multiple Choice: **How many of Dr Rae's lectures did you attend in GM1002?**

1. 0
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6

6. Multiple Choice: **Of Dr Rae's 6 GM1002 lectures (Respiratory & Acid Base) that were vodcasted how many did you view/listen to (either in full or parts of) prior to attending the relevant lecture?**

1. 0
2. 1-2
3. 3-4
4. 5
5. 6

7. Opinion Scale/Likert: **I liked the format of Dr Rae's lectures in GM1002, e.g. more time spent answering / reviewing questions and going over more difficult concepts, rather than delivering a 'conventional', non-participatory, lecture.**

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree
6. Not Applicable

8. Opinion Scale/Likert: **I felt that the format of Dr Rae's lectures in GM1002 (e.g. being asked to review material (lecture slides and/or podcasts) beforehand and answering questions during lecture time) facilitated a greater understanding of the relevant material.**

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree
6. Not Applicable

9. Opinion Scale/Likert: **I would prefer it if Dr Rae stuck to a more conventional lecture delivery style (rather than the style employed in GM1002) in which no prior knowledge is assumed, even if it means rushing through key concepts.**

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree
6. Not Applicable

10. Opinion Scale/Likert: **I would prefer NOT to have to answer questions at all during lectures.**

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree
6. Not Applicable

11. Opinion Scale/Likert: **Of the GM1002 Physiology vodcasts that I have viewed/listened to prior to the relevant lecture, they have helped me to better understand the material and answer the questions presented during the lecture**

1. Strongly Agree
2. Agree
3. Neither Agree nor Disagree
4. Disagree
5. Strongly Disagree
6. Not Applicable

12. Essay: **Please provide any (constructive) comments / suggestions / observations about the vodcasts you feel is of relevance.**

13. Essay: **Please provide any (constructive) comments / suggestions / observations about the format of lectures used by Dr Rae in module GM1002.**

Declaration of Interest

The author has declared that there are no conflicts of interest.