

# WHY DO STUDENTS ACCESS BIOSCIENCE LECTURE RECORDINGS? IS ACCESSING RECORDINGS ASSOCIATED WITH ACADEMIC OUTCOMES?

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## ABSTRACT

When face-to-face lectures are available, there have been limited studies of why students access lecture recordings, and even fewer studies of any association between accessing lecture recordings and academic outcomes. In a bioscience course, a survey was used (i) to determine why the students use lecture recordings and (ii) to test whether there was any association between accessing lecture recordings and academic outcomes. Consenting students undertook an online survey about accessing lecture recordings. Of 288 enrolled students, 131 consented to undertake the survey. For the 84 students who accessed lecture recordings, they were used to clarify, revise or catch up on content, or as an alternative to attending lectures. One-third of students provided additional feedback on accessing lecture recordings, and the most common themes were 'flexibility' and 'useful'. Academic outcomes and accessing lecture recordings were higher for nursing than for non-nursing students. Pearson's correlation coefficients were calculated to determine whether there was an association between accessing lecture recordings and academic outcomes. There were no associations between accessing lecture recordings and academic outcomes. In conclusion, although many students were accessing lecture recordings, accessing recordings alone does not seem to be a major determinant of academic outcomes.

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## INTRODUCTION

Lecture recordings started life as a backbone for distance learning. However, in recent years, access to lecture recordings has been very common for students who have face-to-face lectures. In the COVID-19 era, lecture recordings or other forms of online learning have largely replaced face-to-face lectures.

Undergraduate students who have face-to-face lectures, mostly have a positive attitude towards lecture recordings (e.g. science students; Lyles, Robertson, Mangino & Cox, 2007). There have been several surveys of students about their use of lecture recordings in the human biosciences. For instance, a study of medical students found that the majority accessed lecture recordings to catch up on lectures they had missed with many reviewing lectures they had attended, whereas only a quarter reported using recordings instead of attending lectures (Pilarski, Johnstone, Pettepher & Osheroff, 2008). Almost all students agreed that the lecture recordings helped them study and learn the course material (Pilarski et al., 2008). Some medical students thought that using lecture recordings would improve their grades whereas others thought they would have no effect (Topale, 2016; Hussain, Tabrez, Basu & D'Silva, 2018). Nursing students considered that lecture recordings in the biosciences helped them revisit and revise lectures (Mostyn et al, 2013), enhanced understanding (McKinney and Page, 2009) and grades (Kardong-Edgren & Emerson, 2010). Although nursing students found that having lecture recordings in the biosciences was convenient, they also reported the disadvantages of not providing access to the lecturer and being prone to technology difficulties (McKinney & Page, 2009; Mostyn, Jenkinson, McCormick, Meade & Lymn, 2013). In addition to using lecture recordings to review something missed in class, to review concepts they did not understand, and to catch up on missed lectures, pharmacy students used lecture recordings to control the pace of learning to allow a deeper understanding (Marchand, Pearson & Albon, 2014). One survey of biomedical science students studying pharmacology, linked to academic outcomes, reported that the main reason for accessing lecture recordings was for revision (~85%), followed by clarification, having missed the lecture (~60% of students), and timetabling (Fernandes, Maley & Cruickshank, 2008).

Although it is known that prior academic performance, psychosocial variables, cognitive capability, demographics (reviewed in McKenzie & Schwitzer, 2001) and lecture attendance (Credé, Roch & Kieszczynka, 2010) predict academic performance at university, the relationship between accessing lecture recordings and academic outcomes is less clear-cut. For nursing students, there have been two studies in human bioscience courses, with one study showing poorer academic outcomes (Johnston, Massa & Burne, 2013) and one better outcomes for those that viewed more online lectures (Guy, Byrne & Dobos, 2018). Most studies of other students studying the biosciences have showed no association between use of lecture recordings and grades/attainment (Bollmeir, Wenger & Forinash, 2010; Barco, Gebregziabher & Fitzharris, 2011; Franklin, Gibson, Samuel, Teeter & Clarkson 2011; Leadbeater, Shuttleworth, Couperthwaite & Nightingale 2013; Azab et al., 2016; Edwards & Clinton, 2019; Doggrell, 2020). Other studies have shown that accessing lecture recordings was negatively associated with academic performance (biology students, Simcock, Chua, Heckman, Levin & Brown, 2017; medical students, McNulty et al., 2019; biomedical science students, Doggrell, 2019).

In this study, the first objective was to ask students to give feedback on accessing lecture recordings in the biosciences. The second objective was to test whether there was any association between accessing lecture recordings and academic outcomes, for the bioscience students who were subsequently divided into nursing and non-nursing students. The non-nursing students were mainly studying the biosciences as part of exercise physiology or science programs. As the nursing and non-nursing students were all studying the same bioscience course, any differences observed between them will be independent of the course studied.

## METHODS

At the Queensland University of Technology (QUT), an introductory first-year level, 12 credit point course (96 credits/year is full-time study) bioscience course (Understanding Disease Concepts) has been delivered similarly each semester from 2003 to the present time. It is taught to a mixed cohort, and in semester 2 the students are predominantly nursing students given advanced standing for previous study. Advanced standing students are a mix of graduate and non-graduate students. The graduate students are either international or domestic students with a degree from a university program other than nursing. The non-graduates include those with non-university qualifications, predominantly with a nursing diploma from a college of technical and further education (TAFE), and those with equivalent life or work experience. The non-nursing cohort are predominantly clinical exercise physiology students with some science students. For both cohorts, the Understanding Disease Concepts is a core course, which is built on in future courses. The course is undertaken in the first semester of the two-year program for advanced standing students, and in the second year of the program for clinical exercise physiology.

The course has 3 hours of lecturing per week, over 13 weeks, which were made available via Blackboard as recordings (Echo 360; voice and PowerPoint slides). The course is supported by weekly two-hourly laboratories for 10 weeks. The marks were 60% for the two examinations, which are a mixture of multiple-choice questions (MCQs) and short answer questions (SAQs); 20% for mid-semester (50% MCQs, 50% SAQs) and 40% for the final-semester examination (67% MCQs, SAQs 33%). The ongoing assessment of 40% was for open-book quizzes associated with the laboratories (30% true/false questions, 70% SAQs).

The author was not involved in any aspect of the running or teaching of the bioscience course. The ethical approvals for this research were obtained from the Human Research Ethics Committee; Ethics Approval Number 170000873. During the last laboratory in the semester, written consent was sought from the students by the author to undertake the survey.

Grades for participating students were collated and averaged. Passing grades at QUT are 4 (overall mark, 50-64%), 5 (65-74%), 6 (75-84%) and 7 ( $\geq 85\%$ ). The other academic outcomes measured were the overall mark, marks for both examinations, and for the laboratories.

Part of the survey was to determine the relationship between the use of lecture recordings and academic outcomes. Thus, in consenting, the students were asked to complete the survey, and to allow us to link the findings of the survey to their academic outcomes data. Subsequently, the consenting students were asked, and reminded, to complete the survey in their own time. The survey

was available online, via a link in the course Blackboard page, after consent was sought until the day prior to the final examination.

The survey asked the students to provide their student numbers (IDs), and answer questions about how and why they accessed lecture recordings by ticking all that apply. One of the uses of the IDs was to access the marks of the students for the individual components. Marks were calculated as a percentage of 100% and averaged. To determine Pearson's coefficients accessing lecture recordings were given points: 0 for no attendance/access, 1 for sometimes and 2 for most weeks. Regression line analysis of academic outcomes vs accessing lecture recordings was undertaken, and Pearson's correlation coefficients ( $r$ ) were determined using Microsoft Excel. Correlation coefficients of 0 - 0.19 were considered as very weak, 0.2 – 0.39 weak, 0.4 – 0.59 moderate, 0.6- 0.79 strong, 0.8 – 1.0 very strong (<http://www.statstutor.ac.uk/resources/uploaded/pearsons.pdf>).

Mean values for academic outcomes (overall mark, examinations, mid-semester, final examination, laboratories)  $\pm$  standard deviation (SD) were determined. Individual values for academic outcomes were compared by Student's unpaired t-test with P values of less than 0.05 being considered significantly different. The final question on the survey was "*Please include any additional comments or feedback you have on the use of lecture recordings as a learning tool*", and the responses were evaluated using thematic analysis (Braun & Clarke, 2012).

## RESULTS

The research was undertaken in semester 2 of 2017, and 288 students were enrolled at the start of semester and 234 (81%) attended the laboratory where consent was sought. Forty-six percent of the class (131 students) consented and most were nursing students (84, 64%). The non-nursing students were exercise physiology (37, 28%) or science students (10, 8%).

### RESPONSES REGARDING ACCESSING LECTURE RECORDINGS

The 84 students who responded that they attended lectures 'yes' or 'sometimes' were asked why they accessed lecture recordings, and to tick all that applied. Thirteen of the students did not give a response regarding why they accessed lecture recordings, 30 gave one response, 18 two responses, 12 three responses and 11 students gave 4 responses. The percentage of students for each response is given in Table 1.

**Table 1: Responses from the 84 students who attended lectures regarding accessing lecture recordings**

<b>LECTURE ATTENDEES (yes or sometimes)</b>	
<b>Why did you access the recordings as well as attending the lectures?</b>	
<i>Clarify difficult concepts</i>	44%
<i>Catch up on lectures I missed</i>	44%
<i>Revise lecture concepts for assessment purposes</i>	41%
<i>Reinforce and revise concepts on a regular basis</i>	36%
<i>I find it hard to concentrate in the lecture theatre</i>	5%

### OPEN-RESPONSE FEEDBACK ON LECTURE RECORDINGS

The final question on the survey was to ask the students to add any additional comments or feedback they had on the use of lecture recordings as a learning tool. Forty-eight students (35% of the survey respondents) answered this, with 12 making complementary comments about the lecturer. The main themes of the other 36 pieces of feedback were 'flexibility' and 'useful'. The 15 comments (31%) related to flexibility had 4 distinct points, and representative examples are:

*I think it's fabulous that we have the option of watching lecture recordings online, especially if it's a struggle for people to make it to the lecture. However, I personally prefer face-to-face learning, and would not like to solely rely on lecture recordings.*

*I personally prefer using the lecture recordings as I can alter the speed of the recording, listen to it in chunks at a time instead of all at once, and can go back over parts I do not understand as many times as I need.*

*I like that you can stop and rewind recordings whenever you want/need. I think this allows for better note taking. I also find I get distracted in a lecture theatre environment and prefer to listen to the recordings online as I tend to focus better.*

*It helps reduce stress during the lecture knowing I can make a note to listen to a certain slide again to understand it better*

The second most common theme was 'useful' in 7 (15%) responses:

*It's really useful especially for those who English is not first language.*

*Lecture recordings are a useful study tool, especially when people aren't able to attend the lectures.*

*Lecture recordings are very useful to revise and clarify difficult concepts.*

One student gave feedback linked to both flexibility and usefulness:

*Lecture recordings have been a lifesaver for me. They have been very useful as the lecturer elaborates on information that the slides provide but in a lot more detail. The slides are not always self explanatory, therefore having someone explain each individual slide and giving examples has been very useful. The major downside to the lectures, in general, are that they are very long and I feel that you can lose interest because of this. With the recordings, you can pause and have dinner, regroup, and then get back into it (for example). Also, another positive is that if you missed something when taking notes you can always rewind that section and replay it, or even pause it altogether and look up something you are unsure of before continuing to watch the lecture online.*

Two students suggested the lecture recordings could be improved by including video of the lecturer in them:

*It would be better if we can see the video too with facilitator presenting in class.*

One student preferred the option of having access to face-to-face lectures and lecture recordings:

*I find just lecture recordings without in person lectures a very hard concept to justify being able to get good assessment and exams marks at university. I have two subjects which have been mostly recorded online and I feel I have missed valuable opportunities to expand and grow in this area of academic knowledge. Lecture recordings are excellent as an added tool, not as the only tool.*

## **ACADEMIC OUTCOMES**

Average marks were higher for laboratories than for examinations (Table 2). Nursing students had higher grades, overall marks, and marks for laboratories and the final examinations, than non-nursing students (Table 2).

**Table 2: Academic outcomes**

	All participants n = 131	Nursing n = 84	Non-nursing n = 47
Grade	5.4 ± 1.2	5.6 ± 1.1	5.1 ± 1.0*
Overall mark	73 ± 13	76 ± 12	70 ± 12*
Laboratories	84 ± 11	86 ± 11	81 ± 9*
Examinations	67 ± 17	68 ± 16	63 ± 15
Examination components			
(i) Mid-semester exam	68 ± 20	70 ± 21	65 ± 19
(ii) Final exam	66 ± 16	69 ± 15	61 ± 14*

Each value is mean ± SD, \* P < 0.05 by Unpaired Students' t-test with Nursing students

### ACCESSING LECTURE RECORDING AND ACADEMIC MARKS

As described in the methods, 0 points were allocated for 'no' recording access response, 1 for 'sometimes' and 2 for 'most weeks' or 'weekly'. Data regarding accessing lecture recordings was available for 131 students, and the average points were  $1.39 \pm 0.73$ , and this was significantly higher for the nursing students ( $1.60 \pm 0.65$ ,  $n = 84$ ) than the non-nursing students ( $1.15 \pm 0.78$ ,  $n = 47$ );  $P = 0.0002$ . Table 3 shows there are no significant associations between accessing lecture recordings and academic outcomes.

**Table 3: Correlation coefficients (r) of academic outcomes vs accessing lecture recordings**

	All participants n = 131		Nursing n = 84		Non-nursing n = 47	
	r value	P value	r value	P value	r value	P value
Grade	0.110	0.210	0.180	0.105	0.177	0.233
Overall mark	0.118	0.179	0.135	0.227	0.146	0.329
Laboratories	0.082	0.347	0.153	0.171	0.047	0.756
Mid-semester exam	0.047	0.593	0.153	0.170	0.140	0.350
Final exam	0.108	0.218	0.101	0.366	0.107	0.474

## DISCUSSION

The main findings were (i) lecture recordings were used to clarify, revise or catch up on content, or as an alternative to attending lectures. 'Flexibility' and 'useful' were the common additional feedback for accessing lecture recordings (ii) academic outcomes and accessing lecture recordings were higher for nursing than for non-nursing students and (iii) there were no associations between accessing lecture recordings and academic outcomes.

### RESPONSES REGARDING ACCESSING LECTURE RECORDINGS

The responses from the students in this study of why they access lecture recordings are in line with the previous studies discussed in the introduction.

### SELF-REPORTED LECTURE RECORDING ACCESS

The self-reported lecture recording access was high in this study, and higher for the nursing versus non-nursing students. To my knowledge this is the first time that accessing lecture recordings has been compared between different student cohorts in the same course. The reason for the difference between the cohorts is not known. One possible reason for this is that the nursing students are working more, and more dependent on lecture recording access for study. However, this is not the case, as the survey also asked the students if they were working and more of the non-nursing students (81%) were working than the nursing students (63%). Another possible reason is that nursing cohorts access lecture recordings more than other students. This is unlikely, as it was recently reported (Guy, Byrne & Dobos, 2018) that nursing students accessed lecture recordings less

than other students in bioscience courses. A third possibility is that it is because the nursing students are in an earlier stage of their program (first semester) than the non-nursing students (fourth semester), and students may be more likely to access the lecture recordings at the start of a course. However, most of the advanced standing students had studied before, and this was not their first course. A fourth possibility is that there were more nursing students who do not have English as their first language, and that students without English as a first language may prefer the flexibility of lecture recordings. In the survey, the students were asked if English was their first language, and 72% of nursing students answered 'no' compared to 6% of non-nursing students. Thus, it is possible that the nursing students accessed the lecture recordings more than the non-nursing students, as less of them had English as a first language. This will need to be tested.

### **CORRELATIONS BETWEEN LECTURE RECORDING ACCESS AND ACADEMIC OUTCOMES**

Regression analysis showed no significant associations between accessing lecture recordings and academic outcomes. Previously, where students had face-to-face lectures, studies of any association between the use of lecture recordings and academic outcomes in the human biosciences have given mixed results. For nursing students, there have only been two studies, both in anatomy and physiology courses, with one study showing poorer academic outcomes (Johnston et al., 2013) and one better outcomes for those that viewed more online lectures (Guy et al., 2018). The study of Johnston et al. (2013), compared the results from two campuses, one with and one without the availability of lecture recordings, and the authors noted that differences in student demographics between campuses may have contributed to their findings of poorer academic outcomes with lecture recordings. The present study was performed on one campus, thus variations between demographics on campuses was not an issue. The study of Guy et al. (2018) was also performed on one campus, and the difference in subject score between the lecture recording accessors (~67%) versus non-accessors (~63%) was small but significantly different. Thus, it is possible that the difference in findings between the study of Guy et al. (2018) and the present study may be due to the different ways in which the association between lecture recording access and academic outcomes were assessed. However, in the present study, the overall mark was similar for accessors versus non-accessors, 74% vs 73%. Thus, the different findings between the study of Guy et al. (2018) and this study is not due to the difference in the way the lecture recording access data was expressed. The studies of Johnston et al. (2013) and Guy et al. (2018) used actual lecture recording access data, whereas the present study relied on self-reported access data, and this may have contributed to the different findings between the studies.

Our results with non-nursing students also shows no significant association between accessing lecture recordings and academic outcome. This is in line with most of the previous findings (see Introduction) but differs from three studies showing a negative association (biology students, Simcock, Chua, Heckman, Levin & Brown, 2017; medical students, McNulty et al., 2019; biomedical science students, Doggrell, 2019). In the study by Simcock et al. (2017), lecture recordings were only used by about half of the students, and those that accessed the recordings watched relatively few, and the association between accessors and academic outcomes was weak ( $r = -0.23$ ,  $P = 0.008$ ). A major difference between the study of Simcock et al. (2017) and the present study is that the study of Simcock et al. (2017) excluded non-accessors in the analysis. In the present study, the association between lecture recording access and overall mark, remained insignificant when limited to accessors ( $r = 0.10$ ,  $P = 0.28$ ). In the study of McNulty et al. (2019), students only accessed about 13% of the lecture recordings, and students viewing the fewest lectures (0-7%) had significantly higher grades than those viewing >7%, which contrasts with the present study where the overall mark for accessors and non-accessors were the same. Thus, it seems unlikely that the difference between Simcock et al. (2017) and McNulty et al. (2019) and the present study is due to how the lecture recording data/academic outcomes relationship was expressed. The difference between studies may reflect the different cohorts. It may also be due to lower achieving students distorting the findings to make them negative. Thus, lower achieving students have been shown to access lecture recordings more often than high achievers (Owston, Lupshenyuk & Wideman 2011). Also, one of these studies showed that when a badly failing student was removed, the negative association became no association (Doggrell, 2019).

### **STRENGTHS AND LIMITATION**

The rate of response to the survey was relatively good (48%). A major strength of this study comparing nursing and non-nursing students, was that it was undertaken in the same course, and thus differences between these students cannot be related to the course.

The major limitation is that data on accessing lecture recordings by the students is self-reported, and not corroborated with records of student access to lecture recordings. Unfortunately, at the time of the study, it was not possible to get complete records of lecture recording access by students at QUT. This was because students had the options of downloading the lecture recordings prior to access or accessing them on Blackboard, and records were only available for those students who accessed on Blackboard.

## CONCLUSIONS

Lecture recordings should be made available to students, as the students use them to clarify, revise or catch up on content, or as an alternative to attending lectures, and consider them to offer 'flexibility' and to be 'useful'. However, when face-to-face lectures are available, it should not be assumed that the availability of lecture recordings will improve academic outcomes.

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## REFERENCES

- Azab, E., Saksena, Y., Alghanem, T., Bidle, J.B., Molgaard, K., Albright, S. & Karimbux, N. (2016). Association among dental students' class lecture attendance, use of online resources, and performance. *Journal of Dental Education*, 80(4), 452-458.
- Bacro, T.R., Gebregziabher, M., Fitzharris, T.P. (2010). Evaluation of a lecture recording system in a medical curriculum. *Anatomical Sciences Education*, 3, 300-308.
- Bollmeir, S.G., Wenger, P.J., Forinash, A.B. (2010). Impact of online lecture-capture on student outcomes in a therapeutics course. *American Journal of Pharmaceutical Education*, 74, 127.
- Braun, V., Clarke, V. (2012). Thematic analysis. In Cooper H (Ed). *APA Handbook of Research Methods in Psychology, Chapter 4:57-71*.
- Credé, M., Roch, S.G., Kieszczyńska, U.M. (2010). Class attendance in college: a meta-analytic review of the association of class attendance with grades and student characteristics. *Reviews of Educational Research*, 80, 272-295.
- Doggrell, S.A. (2019). The relationships between lecture attendance or accessing lecture recordings and academic outcomes: results for a pharmacology course in a biomedical science degree. *International Journal of Innovation in Science and Mathematics Education*. 27, 1-12.
- Doggrell, S.A. (2020). No apparent association between lecture attendance or accessing lecture recordings and academic achievement in a medical laboratory science course. *BMC Medical Education* In press
- Edwards, M.R., Clinton, M.E. (2019). A study exploring the impact of lecture capture availability and lecture capture usage on student attendance and attainment. *Higher Education*, 77, 403-421.
- Fernandes, L., Maley, M., Cruickshank, C. (2008). The impact of online lecture recordings on learning outcomes in Pharmacology. *Journal of the International Association Medical Science Educators*, 18, (2).
- Franklin, D.S., Gibson, J.W., Samuel, J.C., Teeter, W.A., Clarkson, C.W. (2011). Use of lecture recordings in medical education. *Medical Science Educator*, 21, 121-129.
- Guy, R., Byrne, B., Dobos, M. (2018). Optional anatomy and physiology e-learning resources: student access, learning approaches, and academic outcomes. *Advances in Physiological Education*, 42, 43-49.
- Hussain, A., Tabrez, E., Basu, A., D'Silva, C.S.M. (2018). Medical student's perception of the usage of lecture recording software. *Cureus*, 10(7), e2963. doi: 10.7759/cureus.2963
- Johnston, A.N.B., Massa, H., Burne, T.H.J. (2013). Digital lecture recording: a cautionary tale. *Nurse Education in Practice*, 13, 40-7.
- Kardong-Edgren, S., Emerson, R. (2010). Student adoption and perception of lecture podcasts in undergraduate Bachelor of Science in nursing courses. *Journal of Nursing Education* 49(7), 398-401.
- Leadbeater, W., Shuttleworth, T., Couperthwaite, J., Nightingale, K.P. (2013). Evaluating the use and impact of lecture recording in undergraduates: Evidence for distinct approaches by different groups of students. *Computer Education* 61, 185-192.
- Lyles, H., Robertson, B., Mangino, M., Cox, J.R. (2007). Audio podcasting in a tablet PC-enhanced biochemistry course. *Biochemistry and Molecular Biology Education* 35(6), 456-461.
- Marchand, J.P., Pearson, M.L., Albon, S.P. (2014). Student and faculty member perspectives on lecture capture in pharmacy education. *American Journal of Pharmaceutical Education*, 78(4), 74. doi: 10.5688/ajpe78474.
- McKenzie, K., Schweitzer, R.D. (2001). Who succeeds at university? Factors predicting academic performance in first year Australian university students. *Higher Education Research & Development*, 20, 21-33.
- McKinney, A.A., Page, K. (2009). Podcasts and videostreaming: useful tools to facilitate learning of pathophysiology in undergraduate nurse education. *Nurse Education in Practice*, 9, 372-376.
- McNulty, J.A., Hoyt, A., Gruener, G., Chandrasekhar, A., Espiritu, B., Price Jr., R., Naheedy., R. (2009). An analysis of lecture video utilization in undergraduate medical education: associations with performance in the courses. *BMC Medical Education* 9(6), doi: 10.1002/ase.184.
- Mostyn, A., Jenkinson, C.M., McCormick, D., Meade, O., Lymn, J.S. (2013). An exploration of student experiences of using biology podcasts in nursing training. *BMC Medical Education*, 13(12). doi: 10.1186/1472-6920-13-12.
- Owston, R., Lupshenyuk, D., Wideman, H. (2011). Lecture capture in large undergraduate classes: student perceptions and academic performance. *The Internet and Higher Education*, 14, 262-268.
- Pilarski, P.P., Johnstone, A., Pettepher, C.C., Osheroff, N. (2008). From music to macromolecules: using rich media/podcast lecture recordings to enhance the preclinical educational experience. *Medical Teacher*, 30(6), 630-632.

Simcock, D.C., Chua, W.H., Heckman, M., Levin, M.T., Brown, S. (2017). A survey of first-year biology student opinions regarding live lectures and recorded lectures as learning tools. *Advances in Physiological Education*, 41(1)69-76. doi: 10.1152/advan.00117.2016.

Topale, L. (2016). The strategic use of lecture recordings to facilitate and active and self-directed learning approach. *BMC Medical Education*, 16(1), 201. doi: 10.1186/s12909-016-0723-0.