Article:

Pickering, JD orcid.org/0000-0002-0494-6712 and Swinnerton, BJ orcid.org/0000-0002-4241-4952 (2019) Exploring the Dimensions of Medical Student Engagement with Technology-Enhanced Learning Resources and Assessing the Impact on Assessment Outcomes. Anatomical Sciences Education, 12 (2). pp. 117-128. ISSN 1935-9772

https://doi.org/10.1002/ase.1810

ASE-18-0062

Research Report

Exploring the Dimensions of Medical Student Engagement with Technology-Enhanced Learning Resources and Assessing the Impact on Assessment Outcomes

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Running title: Medical Student Engagement with TEL resources

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ABSTRACT

Anatomy curricula are becoming increasingly populated with blended learning resources, which utilize the increasing availability of educational technology. The educational literature postulates that the use of technology can support students in achieving greater learning outcomes by increasing engagement. This study attempts to investigate the dimensions of student engagement with technology-enhanced learning (TEL) resources as part of a medical program's anatomy curriculum using exploratory factor analysis. A 25-item five-point Likert-based survey was administered to 192 first-year medical students, with three emergent factors discerned: satisfaction, goal setting and planning, and physical interaction. The three factors closely aligned with the existing literature and therefore additional non-parametric analysis was conducted that explored the levels of engagement across three custom-made anatomy TEL resources, including: 1) anatomy drawing screencasts; 2) an eBook; and 3) a massive open online course (MOOC). Usage data indicated that the most popular resource to be accessed across the cohort was the anatomy drawing screencasts via YouTube, with the MOOC being used least. Moreover, some evidence suggests that those students who utilized the MOOC, were more engaged. Generally, however, no correlations were observed between the levels of engagement and TEL resource usage or assessment outcomes. The results from this study provide a clear insight into how students engage with TEL resources, but does not reveal any relationship between levels of engagement, usage and assessment outcomes.

Keywords: gross anatomy education, medical education, anatomy education, undergraduate education, engagement, blended learning, motivation, technology-enhanced learning, assessment

INTRODUCTION

Blended Learning Curricula

Anatomy curricula are utilizing an ever-increasing amount of modern technology to create blended learning environments, which combine the traditional face-to-face teaching experiences with a range of online activities (Khalil et al., 2018). These courses are, therefore, designed to be rich in learning opportunities that are both flexible and accessible, with the aim to support student engagement and motivation in acquiring the desired course objectives. The development of such courses has been supported by the continual upsurge in the availability and affordability of technology-enhanced learning (TEL) resources, such as custom-built hardware solutions, high-powered desktop computers, mobile tablets and smart phones, that drive the use of increasingly sophisticated software applications (Trelease, 2016). The literature is becoming increasingly populated with examples of how this type of technology is supplementing anatomy curricula, with the use of, for example, eBooks (Stirling and Birt, 2014; Pickering, 2015a), smart phone and tablet applications (Lewis et al., 2014), social media (Hennessy et al., 2016; Pickering and Bickerdike, 2017), massive open online courses (MOOCs; Swinnerton et al., 2017), 3D printed specimens (McMenamin et al., 2014; Lim et al., 2016), 3D visualizations (Yammine and Violata, 2015), and most recently, augmented and virtual reality (Moro et al., 2017), all being documented. This emphasis on augmenting the traditional anatomy curricula with TEL resources has recently been supported by a meta-analysis of blended learning courses across healthcare education, which highlights the positive impact such courses can have on student outcomes (Liu et al., 2016; Wilson et al., 2018).

Additional factors that have prompted this change in approach to curricula delivery, include: 1) a reassessment of the amount of time that is dedicated to anatomy learning in modernizing medical programs (Heylings, 2002; Drake et al., 2014; Pawlina and Drake, 2017; McBride and Drake, 2018); 2) the level of detailed anatomy necessary for undergraduate students (McKeown et al., 2003; Turney, 2007; Louw et al., 2009); and 3) the availability and logistics of maintaining an anatomy teaching facility that utilizes cadaveric material (McLachlan, 2004; McLachlan and Patten, 2006). It is in this context of a changing anatomy education landscape that numerous courses are now being described that fully integrate online material as a main learning tool used to deliver the required learning objectives (Wright, 2012; Attardi et al., 2016; Green and Whitburn, 2016; Attardi et al., 2018). This diffusion of TEL resources into anatomy education has occurred concurrently with the emergence of students believed to exhibit high-levels of digital literacy (DiLullo et al., 2011). The concept of 'digital natives' (Prensky, 2001) may no longer be accepted as an accurate depiction of the current student population, but terms such as Millennials, and most recently, Generation Z (Strauss and Howe, 1991; Oblinger and Oblinger, 2005; Povah and Vaukins, 2017) are still used widely. These students are generally born after 1982 (Strauss and Howe, 1991), and are characterized as being totally reliant on the internet, and accomplished and efficient multi-taskers (DiLullo et al., 2011). This perceived cultural change in attitude to accessing education has contributed to the belief that students nowadays require education that is delivered through the technology they are accustomed to, and have been immersed in, for their entire lives (Sandars and Morrison, 2007; Ituma, 2011). Furthermore, through this prism of cultural change and the emergence of such social constructs within society, a hypothesis has been put forward that suggests that increasing the amount of technology integrated within a course will lead to enhanced engagement with curricular content, and a concomitant improvement in learning outcomes (Coates, 2005; Shea et al., 2006; Krause and Coates, 2008; Rodgers, 2008; Green et al., 2018). However, although this educational landscape may appear intuitive and a reasonable basis for introducing TEL resources, several authors have questioned the usefulness and accuracy of this portrayal, finding that those born in the 1980-90s may not be as homogenous as originally thought (Margaryan et al., 2011; Kennedy and Fox, 2013; Selwyn, 2016; Kirschner and De Bruyckere, 2017). Margaryan et al. (2011) found that university students use a limited range of technologies to support their learning and '*are far from constantly connected'* when it comes to using personal and mobile devices. Moreover, the study highlighted a failure to exhibit specific generational learning approaches that were radically different from previous generations, or had expectations of their higher education that were particularly novel, finding that students expected to be taught in fairly traditional ways (Margaryan et al., 2011). A more recent study from Kennedy and Fox (2013) found that although first-year university students were frequent users of digital technologies for their own *'personal empowerment and entertainment'*, in regard to using technology to support their learning they were not digitally literate (i.e., able to effectively utilize technology to specifically support their own learning).

Student Engagement

Across higher education there is a longstanding desire to support and enhance student engagement, with faculty continually endeavoring to create effective and efficient learning activities. Engagement within the educational environment can be viewed as the *'quality of* effort students themselves devote to educationally purposeful activities that contribute *directly to desired outcomes'* (Krause and Coates, 2008). This view of student engagement draws on the constructivist approach to learning, in that students construct their own knowledge by drawing on the institutions and faculty members who aim to create suitably innovative learning environments (Davis and Murrell, 1993; Dixson, 2015; Krahenbuhl, 2016). Considerable work has attempted to better understand the underlying dimensions of engagement, with three key domains being identified that directly relate to how a student interacts with their academic experience; these are emotional, behavioral and cognitive (Trowler, 2010). For example, a student who is engaged emotionally could be considered to exhibit signs of *'en*joyment*'* and *'interest'* in both the course and its contents; a behaviorally-engaged student would be *'actively participating'* in both classroom activities and online resources; and a student who is engaged cognitively would be one who is *'invested'* in their learning and seeks to explore content *'beyond'* what is required. Although these domains are observed throughout the academic activities of a course, they also encompass the relationship students have with the surrounding infrastructure and social environment. This broad conceptual view has been further explored leading to a number of scales being developed that aim to understand the varied aspects of engagement, including: transition, academic, peer, student-staff, intellectual, online, and beyond-class (for review see Krause and Coates, 2008).

Given the drive to incorporate more technology into modernizing anatomy curricula, and the construct of student engagement having an increasingly prominent role in higher education, the need to focus on links between the two is becoming vitally important. Having a greater understanding of this dynamic relationship is essential when supporting the development of new and innovative anatomy curricula. Engagement, however, is only one of several associated psychological constructs that are currently under the spotlight across anatomy education, with research emerging that specifically focuses on self-efficacy, self-regulation, self-directed learning and motivation (Naug et al., 2011; Burgoon et al., 2012; Abdel Meguid and Khalil, 2016; Choi-Lundberg et al., 2016). Although there is considerable interplay between these aspects of student interaction within a course, limited work within anatomy education is available that conceptualizes student engagement as a social construct in itself, especially in regard to TEL.

Background and Research Questions

In an attempt to explore the underlying self-perceived behaviors and attitudes of students enrolled across higher education programs, self-report instruments are the predominant approach for collecting reliable data in a variety of different contexts. In the context of this study, which is specifically aimed at exploring the levels of student engagement with TEL resources during a medical program's anatomy curriculum, a number of engagement scales were reviewed and considered during the exploratory phase of the research. Three scales were identified, including: (1) the self-regulated learning and motivation scale (Fontana et al., 2015; Milligan and Littlejohn, 2016), (2) the online engagement scale (Krause and Coates, 2008), and (3) the student engagement scale (Gunuc and Kuzu, 2015). These three scales provided a useful starting point for the creation of items, but as their focus was not specifically on TEL resources integrated into a campus-based blended learning curriculum, items from these scales were only used as a guide with others drawn from the wider literature.

The work conducted in this study, primarily attempted to identify the underlying dimensions of student engagement with technology incorporated into a medical anatomy program, and then secondarily to explore any potential links between the emerging patterns of behavior with learning outcomes. These aims were explored via the following research questions: (1) What patterns of engagement underlie the use of TEL resources within a medical anatomy curriculum and are these related to levels of usage or gender? and (2) Do these emergent patterns correlate with assessment outcomes?

MATERIALS AND METHODS

Development and Deployment of Technology-Enhanced Learning Engagement Scale

The TEL engagement survey used in this study consists of 25 items, which were generated after reviewing three previously identified scales that focused on student engagement and self-regulated learning (Krause and Coates, 2008; Gunuc and Kuzu, 2015; Fontana et al., 2015; Littlejohn et al., 2016). Each item was measured using a five-point Likert scale based upon positively phrased inferences, with each rating assigned a score as follows: strongly disagree, 1; disagree, 2; neither agree nor disagree, 3; agree, 4; strongly agree, 5. The survey also asked for information about gender, and student ID to be able to match responses to assessment outcomes. The TEL engagement scale was deployed to Year 1 medical students at the University of Leeds, United Kingdom, as part of the integrated anatomy component of the Bachelor of Medicine and Bachelor of Surgery (MBChB) program. The survey was paper-based and was administered to the cohort in a teaching session which took place once the specific module's teaching and assessment had been completed.

Participants and Curriculum

The Year 1 integrated anatomy component (Body Systems) includes the anatomy, physiology, and relevant clinical considerations, of the major functional systems associated with the human trunk (e.g., respiratory, cardiovascular, gastrointestinal, renal and reproductive). During the module, each student receives 60 hours of contact time in relation to the anatomy strand, divided into lectures (21 hours), dissection-based practical classes (29), living anatomy and radiology small group sessions (4 hours), and tutorials (6 hours). To support these teacher-led sessions several self-directed learning resources were provided, including a paper-based work-book, online formative multiple-choice questions (MCQs), and cadaver demonstration videos. Specifically, in relation to the gastrointestinal and renal systems three additional TEL resources were made available, including: (1) an anatomy MOOC on abdominal anatomy (Swinnerton et al., 2017); (2) an iBook specifically relating to the anatomy of the abdomen (Pickering, 2015a); and (3) a YouTube channel featuring 19 anatomy drawing screencasts on the anatomy of abdomen (Pickering, 2015b). The anatomy strand of the module is assessed via two timed spotter-style examinations similar in format to objective structured practical examinations (OSPEs; Yaqinuddin et al., 2013). Both spot tests contain 90 multiple choice questions (MCQs; single best answer) or extended matching questions (EMQs), which are distributed over 30 stations that contain either gross anatomical or osteological specimens, radiographs, or photographed human models to highlight surface structures. Each station contains three MCQs or three EMQs that assess both basic knowledge and application. The first spot test (spotter 1) covers the anatomy related to the respiratory and cardiovascular themes (worth 40% of overall grade), with the second test (spotter 2) covering the gastrointestinal, renal and reproductive themes (worth 60% of overall grade). The results from each test are aggregated with compensation permitted so that for a student to successfully complete the module they are required to pass overall once their two spotter scores have been combined. The spotter standard is calculated via the Ebel procedure (Ebel, 1951; Ben-David, 2000). For the purposes of this study only questions relating to the gastrointestinal and renal themes within the second spot test, which were specifically supported by the additional three TEL resources, were used.

Ethical approval for the study was granted from the Research Ethics Committee of the University of Leeds School of Medicine (protocol: MREC 15-002).

Data Analysis

Descriptive statistics for the individual TEL resource usage were calculated and analyzed. Statistical significance was determined using either Chi-squared (χ^2) or Fisher's Exact test

(FET; when the number of expected counts was < 5) for ordinal data obtained via the questionnaire, with 2 x 4 contingency tables formed from Gender and levels of TEL usage (used a lot, used sometimes, used a little, did not use). To calculate the level of usage with the three TEL resources that supported the gastrointestinal and renal aspects of the Body System module, a specific section at the beginning of the survey asked: (1) 'Which TEL resources did you access during the Body Systems anatomy teaching', and (2) to detail the extent to which they utilized that resource (e.g., used a lot, 3; used sometimes, 2; used a little, 1; did not use, 0). By summing the scores for each TEL resource an overall usage score per student could be ascertained with a maximum value of 9 (i.e., students who used all three resources a lot) and a minimum value of 0 (i.e., students who did not use any of the resources).

To determine if a factor structure emerged from the TEL engagement instrument, exploratory factor analysis (EFA) was conducted, with principle component analysis (PCA) as the method of factor extraction. To ensure sampling adequacy the Kaiser-Meyer-Olkin (KMO) value was examined, with a value > 0.6 required. Bartlett's test of sphericity was also calculated to ensure the correlation between items was sufficient, with a significant ($p < 0.05$) result required (Field, 2009). To determine the number of factors, a range of analytical and subjective techniques were used, including: (1) Kaiser's criterion of eigenvalues being > 1; (2) scree plot analysis; and (3) parallel analysis (Watkins, 2005). The primary objective of the EFA in this study was to generate a solution that was interpretable and parsimonious. Therefore, the following three criteria were used: (1) each factor was required to have a minimum of 4 items loaded; (2) only items with a factor loading > 0.4 are reported; and (3) objective judgements on factor interpretation were made. Individual TEL engagement scores were calculated for the whole instrument and for emergent factors by summing the responses from each of the retained items, with the minimum (number of retained items multiplied by 1) and maximum (number of retained items multiplied by 5) scores used to calculate a mean, median and ± standard deviation (±SD). Normality (Shapiro-Wilks) tests, supported by quantile-quantile (QQ) plots to determine the common distribution of populations from the data sets, revealed that the distribution of assessment outcomes, usage of the individual TEL resources, and the overall and emergent engagement factors 1and 3 were not normally distributed, with P-values of < 0.01 recorded. Factor 2 was distributed normally with a P-value of 0.212. Therefore, non-parametric tests were used to evaluate the relationships between engagement and use, engagement and outcomes, and use and outcomes.

Summed responses for each of the identified factors were analyzed for statistical significance using Mann-Whitney U tests, Independent Samples Kruskal-Wallis H tests with post-hoc pairwise comparisons, and correlation (Spearman) coefficients for comparisons on Gender, level of TEL use and impact on assessment, respectively. To assess the internal reliability of the instrument, and emergent factors, Cronbach's alpha was calculated with a value between 0.70 and 0.95 deemed acceptable (Tavakol and Dennick, 2011). An alpha level was set at 0.05 for all statistical tests. Likert scale data from the questionnaire are treated as continuous and presented as mean ± SD.

All data were sorted, coded and analyzed using Statistical Package for Social Sciences (SPSS), version 22 (IBM Corp., Armonk, NY), with Excel 2015, version 15.14 (Microsoft Corp., Redmond, WA) used to generate graphs for figures which were then exported to Illustrator, Adobe CS6, version 16.0.4 (Adobe Systems Software, Ireland Ltd., Dublin, Ireland) for editing.

RESULTS

Cohort Demographic and Survey Completion Rate

During the academic year 2015/16, 232 Year 1 medical students completed the compulsory 17-week MBChB Body Systems module. Of these, 192 (82.8%) completed the TEL engagement survey, with 2 not disclosing their Gender. From the 190, 120 (62.5%) identified as female and 70 (36.5%) as male. The Gender distribution of those who completed the survey did not differ significantly from the MBChB Year 1 cohort (female, 138 [59.5%]; male, 95 [40.5%]; χ^2 (1, n = 422) = 0.593, P = 0.44).

Level of Self-Perceived Technology-Enhanced Learning Resource Use

The vast majority of students (99.0%) accessed YouTube, a large majority accessed the iBook (76.0%), and a much smaller proportion accessed the MOOC (39.6%) as a resource to support their learning. No gender differences in access were observed for screencasts via YouTube (FET, P = 0.76) or the MOOC, χ^2 (3, n = 190) = 0.726, P > 0.05, but a significant difference was noted for the use of the iBook, χ^2 (3, n = 190) = 8.716, P = 0.033, showing females used it significantly more than males.

Furthermore, analyzing the level of usage for each of the resources from those who stated they utilized them, revealed that not only were the screencasts accessed by the majority of the students, they were also used most extensively, χ^2 (3, n = 412) = 228.19, P < 0.001. Figure 1 displays that of the 190 students who accessed the screencasts via YouTube, 83.2% used them a lot, 12.6% used them sometimes, and 4.2% used them a little. For both the iBook and the MOOC the level of use was much lower, with 43.8% and 34.2% using them a lot, 27.4% and 23.7% using them sometimes, and 28.8% and 42.1% using them a little, respectively.

Technology-Enhanced Learning Engagement Factor Determination

Exploratory Factor Analysis. To determine the factor structure of the TEL engagement scale, EFA was performed on the responses from 192 Year 1 medical students. Initial analysis of the data set revealed both the KMO measure (0.848) and Bartlett's test of sphericity, χ^2 (300) = 1396.1, P <0.001, were deemed to be adequate. Subsequently, PCA was used as the method of factor extraction with an orthogonal (varimax) rotation revealing an initial 7 factor structure. Each factor had a Kaiser's criterion > 1 and together the 7 factors explained 59.62% of the total variance. The internal reliability of the 25-item scale was calculated as very good with a Cronbach's alpha of 0.864 recorded. The factor structure was assessed by examining the scree plot and comparing the eigenvalues to those generated by parallel analysis. Furthermore, the rotated component matrix was examined to ensure that each factor had at least 4 items loaded. Due to the scree plot not yielding a clear point of inflection, parallel analysis suggesting only 3 factors should be retained, and factors 6 and 7 only having 3 items loaded, respectively, further cycles of EFA were performed by prompting for incrementally fewer factors and removing items which failed to load onto at least 1 factor. This repeated analysis, resulted in items 3, 4, 5, 7, 8, and 18 being removed from the scale, with all remaining items having a factor loading of > 0.4, and each factor having a minimum of 4 items loaded. The KMO (0.860) and Bartlett's test of sphericity, χ^2 (171) = 1103.699, P <0.001, of the final items were both deemed to be appropriate. PCA of the remaining 19 items revealed a 3 factor structure (Table 1), with each factor having a Kaiser's criterion > 1 and collectively accounting for 47.71% of the total variance explained. Analysis of the scree plot, parallel analysis and objective judgement of the individual items loading onto each factor, led to the 3 factor structure being retained. The internal reliability of the final 19-item scale was calculated as very good, with a Cronbach's alpha of 0.867 recorded.

Factor Structure and Correlations. As a result of the EFA a three factor structure was identified (F1-F3), representing the dimensions that underlie the engagement with TEL resources. Each factor accounts for a different dimension of TEL engagement and is described as follows, with number of loaded items, the reliability of the factor and the total variance explained provided:

- Factor 1: Satisfaction (8 items; Cronbach's alpha = 0.847; total variance explained = 31.31%) relates to the extent to which a student is willing to utilize TEL resources, their desire to locate the TEL resources, and the sense of fulfillment having interacted with the TEL resource.
- Factor 2: Goal setting and planning (7 items; Cronbach's alpha = 0.734; total variance explained = 9.21%) relates to the extent to which a student is setting short- and long-term goals and immersing themselves in the content of the TEL resource.
- Factor 3: Physical interaction (5 items; Cronbach's alpha = 0.717; total variance explained = 7.19%) relates to the extent to which a student actively participates with the TEL resource.

To assess if the individual factors within the TEL engagement scale were related the instrument was tested for inter-factor correlation. Correlation analysis was performed between the three factors identified (Table 2) and revealed a significant positive relationship between each of the engagement dimensions.

Factor Scores and Comparisons Between Gender. To assess if any differences in the overall TEL engagement scale and the emergent factors existed between Gender, level of usage and assessment outcomes, the individual scores for each student were calculated. The minimum and maximum scores possible for the overall TEL engagement scale and individual factors are as follows: overall scale (19 items) had possible minimum and maximum scores of 19 and 95, respectively; Factor 1 (8 items) had scores of 8 and 40, respectively; Factor 2 (7 items) had scores of 7 and 35, respectively; Factor 3 (5 items) had scores of 5 and 25, respectively. The average score for students on the overall TEL engagement scale was 73.3 ± 9.4 (77.2% engagement; n = 181), for Factor 1 it was 32.9 ± 5.0 (82.3% engagement; n = 192), for Factor 2 it was 23.2 ± 4.3 (65.7% engagement; n = 186) and for Factor 3 it was 21.0 ± 2.8 (84.0% engagement; n = 187). The scores for female and male students are provided in Table 3, with no statistical difference observed for the overall TEL engagement scale, U = 3661.5, P = 0.787; Factor 1, U = 4035.0, P = 0.651; Factor 2, U= 3789.0, P = 0.656, or Factor 3; U = 3928.0, P = 0.832.

Comparisons Between Engagement and Usage. A Kruskal-Wallis test was performed to assess if any differences existed between the overall TEL engagement scores and individual factors, and the self-perceived level of usage for the MOOC, iBook and YouTube channel. Table 4 details the results and reveals a significant difference in MOOC usage for Factor 1, χ^2 (2) = 9.387, P = 0.009, with follow up comparisons highlighting a difference between used a lot and used a little (P = 0.007). In regard to iBook usage a significant difference was observed for the overall TEL engagement scale, χ^2 (2) = 6.051, P = 0.049, with follow up comparisons highlighting a difference between used a lot and used a little (P = 0.051). For the YouTube channel a significant difference in usage was observed for the overall TEL engagement scale, χ^2 (2) = 15.285, P < 0.001, with follow up comparisons highlighting a difference between used a lot and used sometimes (P = 0.011), and used a lot and used a little (P < 0.013); for Factor 1, χ^2 (2) = 23.057, P < 0.001, follow up comparisons revealed a difference between used a lot and used sometimes (P < 0.001), and used a lot and used a little (P < 0.015); and for Factor 3, χ^2 (2) = 11.903, P = 0.003), follow up comparisons revealed a difference between used a lot and used sometimes (P = 0.019), Comparisons Between Engagement and Assessment Outcomes. To investigate the relationship between the students' overall TEL engagement scale and individual factor score, the linear correlation (Spearman's) coefficient was calculated using the students' assessment marks from the relevant questions contained within the second Body Systems' spotter test. No significant correlation was observed for the overall TEL engagement scale, $r = 0.108$ ($n = 161$, $P > 0.05$); Factor 1, $r = 0.126$ ($n = 172$, $P > 0.05$); Factor 2, $r = 0.103$ ($n = 166$, $P > 0.05$); and Factor 3, $r = -0.036$ ($n = 137$, $P > 0.05$). In addition, no significant correlation was observed in regard to TEL engagement and how students performed on the first Body Systems' spot test, with the overall TEL engagement scale, $r = 0.028$ ($n = 181$, $P > 0.05$); Factor 1, $r = 0.063$ ($n = 192$, $P > 0.05$); Factor 2, $r = 0.050$ ($n = 186$, $P > 0.05$); and Factor 3, $r = -0.054$ ($n = 187$, $P > 0.05$; Table 5).

A further Kruskal-Wallis test was performed to determine if any differences were present between the level of usage and assessment outcomes for the second Body Systems assessment (spotter 2). No significant difference was observed between the levels of usage and assessment outcomes for the overall TEL resources, χ^2 (8) = 3.997, $P < 0.857$, the MOOC, χ^2 (3) = 5.065, $P < 0.167$, the iBook, χ^2 (3) = 2.747, $P < 0.432$, and the YouTube channel, χ^2 (3) = 0.660, $P < 0.883$.

DISCUSSION

Recent changes in anatomy education have led to the increasing integration of TEL resources within curricula to support the development of blended learning environments. This emergence has occurred concomitantly with the classification of students as Millennials or Generation Z (Strauss and Howe, 1991; Oblinger and Oblinger, 2005; Povah and Vaukins, 2017), who are supposedly dependent and accomplished users of modern technology for both their learning and social activities (DiLullo et al., 2011). Although the literature is mixed on the degree to which students are inherently predisposed to high levels of competency with TEL resources (Margaryan et al., 2011; Kennedy and Fox, 2013; Selwyn, 2016; Kirschner and De Bruyckere, 2017), it is widely postulated that by promoting the use of such electronic resources students will have increased engagement and enhanced learning outcomes (Coates, 2005; Shea et al., 2006; Krause and Coates, 2008; Rodgers, 2008). This study characterized the dimensions of engagement with a range of TEL resources by Year 1 medical students participating in a compulsory anatomy module, and has shown there to be three clear areas: satisfaction, goal setting and planning, and physical interaction. The data presented describe the how aspects of engagement, with considerations on the impact and why provided.

Patterns of Engagement with Technology-Enhanced Learning Resources

In deploying multiple rounds of EFA three emergent factors, or dimensions, were discerned that describe the range of interaction students have with anatomy TEL resources. All three factors had a good level of internal reliability, indicating that the clustered items within each factor were accurately identifying a specific dimension and were accurate descriptions of engagement. The factors also exhibited high convergent validity, indicating the close association between factors. The three emergent dimensions of engagement: satisfaction, goal setting and planning, and physical interaction, support previous findings and are closely aligned with the broad understanding of student engagement as emotional, behavioral and cognitive (Trowler, 2010; Gunuc and Kuzu, 2015).

The first factor to emerge from the TEL scale was satisfaction, with items 1 (I enjoy using a range of TEL resources), 24 (I heavily engage with the TEL resources), and 20 (I like using TEL resources) loading highly together, and clearly presenting an aspect of engagement that is of learner satisfaction, enjoyment and pleasure. This finding confirms previous work from both the same medical anatomy course in Leeds and elsewhere, which has highlighted how students find satisfaction in engaging with TEL resources as part of their anatomy and medical education (Pickering, 2015b; McCoy et al., 2016; Swinnerton et al., 2017), and general conforms to the idea of emotional engagement. Satisfaction with a learning resource, be it TEL or otherwise, is an unsurprising, yet important result as a resource that is enjoyed will often be used repeatedly during a course, and can serve as an important gateway for increased engagement (Kirschner, 2016). However, it must be noted that although student satisfaction with a resource is an inherently good thing – educators want students to enjoy their learning experience – student satisfaction with a resource should not be conflated with enhancements in learning (Dixon, 1990; Jamieson-Noel and Winne, 2002; Kirkwood and Price, 2014).

The second dimension to emerge from the engagement scale was defined as goal setting and planning, with items 13 (I set myself goals before I learn with TEL resources), 9 (I plan ahead to incorporate my TEL resource use) and 21 (I plan my learning when using the TEL resource) loading highly together. This outcome conforms to an element of cognitive engagement where students are sufficiently aware and knowledgeable of their curriculum to effectively plan and set-targets (Trowler, 2010). This meta-cognitive aspect of engagement has been documented extensively across the wider literature (Flavell, 1979; Zimmerman et al., 1989; Pickering, 2017), and highlights how students who are suitably conscious of their own understanding and knowledge base can plan and set targets that are relevant and appropriate. Students who exhibit this type of behavior have been shown to have enhanced benefits, in both learning experiences (Naug et al., 2011) and outcomes (Pickering and Bickerdike, 2017).

The third dimension of student engagement was termed physical interaction with items 22 (I make notes when using the TEL resource), 17 (I carefully listen when using TEL resources) and 19 (I go over the TEL resource in detail) loading highly and revealing an active approach that aligns with behavioral engagement. Although the behavioral engagement by a student with learning resources can align with a number of diverse behaviors that are dependent on the specific learning environment in which the resource is situated, this active rather than passive level of interaction indicates a meaningful involvement with the resources. This degree of interaction has been observed previously with studies that have focused on similar types of TEL resources that contain content that is best suited to active participation, such as drawing (Noorafshan et al., 2014; Backhouse et al., 2016; Pickering, 2016) with this approach to learning supported by robust empirical evidence (Van Meter and Garner, 2005; Van Meter et al., 2006; Schwamborn et al., 2010).

In summary, this study has for the first time explored the behavior of students with TEL resources in regard to engagement across a medical anatomy program. The findings are reassuring as they closely align with previous interpretations of engagement across higher education, and begin to unravel how students are engaging with TEL resources.

Interplay between engagement, usage and assessment outcomes

The interplay between engagement, TEL resource usage and assessment outcomes is understandably complex, with some inherent limitations. However, attempting to provide an explanation for how students engage with TEL resources and the impact of such activity is important and was the focus of the second research question. Data suggest that all students within the cohort were highly engaged. By reporting the levels of engagement as a proportion of the maximal levels of engagement by emergent factor, only Factor 2 (Goal setting and planning) was found to be below 70%. As this type of behavior supports a level of cognitive or meta-cognitive engagement, it is not surprising that this one factor was the lowest recorded. Nevertheless, the overall findings indicate that all students enrolled on the Body Systems module were highly engaged with the TEL resources provided. Intuitively, it would seem logical that students who are highly engaged with their curriculum would perform better in assessments (Coates, 2005; Shea et al., 2006; Krause and Coates, 2008; Rodgers, 2008; Green et al., 2018), but within the education literature skepticism exists as to the full extent engagement can be used as an accurate proxy for learning (Mayer, 2004; Mcconney et al., 2014; Garon-Carrier et al., 2016).

Taken at face value the results from this study would appear to support the latter view, as no correlation was observed between factor score and assessment outcomes. However, a cautionary note should be applied as the underlying levels of engagement within this cohort were measured to be consistently high, and did not reveal a full spread of student engagement levels that could be correlated against assessment scores. Furthermore, no correlation was observed with students who had performed well in the first spotter assessment indicating no clear linkage between prior academic achievement and TEL resources engagement. These findings are in contrast to recent work that showed engagement can serve as a predictor for assessment outcomes (Green et al., 2018). However, although these findings may appear to be contradictory, it is important to note the differences in approach and interpretation of engagement across the two projects.

What is evident from the study was the ubiquitous use of YouTube across the cohort, with the iBook and MOOC used much less. The use of YouTube in anatomy education is common with several authors commenting on its role to support the 'Millennial' generation of students, with one study documenting a 98% usage rate of YouTube resources (Jaffar, 2012; Barry et al., 2016). However, its use is not without shortfalls with Raikos and Waidyasekara (2014) revealing a lack in both the production quality and academic accuracy of resources posted online, and Azer (2012) reporting that a high proportion of surface anatomy videos found on YouTube were not educationally useful. The variable quality of resources located within this medium has drawn attention to the need for more robust ethical and pedagogical frameworks to support their integration and ensure students are being directed to content that is accurate and relevant (Barry et al., 2016). The underlying reasons for YouTube being accessed by the vast majority of students compared to the iBook and MOOC in this study is less clear. It could be postulated that the ease of access, brevity of the anatomy drawing screencasts hosted by the channel, and that the producer of the content was also the course instructor, could all provide some possible explanations. The use of the iBook and MOOC to a lesser degree may not be surprising as although both resources contained content that was in addition to the anatomy drawing screencasts, such as quizzes and clinical vignettes, this supplementary material was also readily available elsewhere in the blended anatomy curriculum of Body Systems. Previous research on the integration of MOOCs into an anatomy curriculum has suggested that the massive and open elements were not significant drivers for engagement, with students simply wanting access to the high-quality and professional resources such courses create (Swinnerton et al., 2017). This contrasts with learners in the workplace who are without a highly scaffolded course to structure their learning (Laurillard, 2016; Pickering and Swinnerton, 2017), and may suggest that students enrolled on on-campus courses are content with the highly scaffolded program already in place. However, it did appear that a subset of students did access the MOOC alongside the other resources, with these students scoring highly on the satisfaction factor only. This may be accounted for by the novelty of a MOOC, which only attracted those students who were particularly inclined to seek such resources to support their learning. However, without any indication that students who scored highly for goal setting and planning, this engagement was conducted trivially rather than strategically. A similar pattern of behavior was also observed amongst the students who utilized the iBook, with only those students who were particularly enthusiastic about TEL. These findings, alongside the generally lower engagement values found with students who accessed YouTube, would suggest this to be the go-to resource due to the features of accessibility, content provider, and bite-size video length outlined. Generally, it would appear that it was those students who were most engaged who accessed the lesser-used resources, including the iBook and MOOC; however, the levels of engagement exhibited by students as measured in this study did not appear to be a predictive factor for assessment scores.

Drivers for Engagement

Given the poor correlation between the TEL engagement scale and students' assessment outcomes, a pragmatic summary could suggest that although some students may seek out certain resources for their own enjoyment, or to physically interact in a meaningful way, or to organize and structure their consolidation and revision, for the majority of students they are simply the most appropriate and convenient vehicle to drive and support their learning. Of course, students engaging with any resource that supports their learning is advantageous, but perhaps alternative factors are determining why they engage with learning resources, with technology-based resources being one of several within a blended learning curriculum. It has been described previously that assessment is a significant driver towards student learning, especially when this assessment is of a high-stakes nature, such as the spotter examination in this study (McLachlan, 2006; Wormald et al., 2009; Cilliers, 2015). Wormald et al. (2009) provided clear evidence that the higher weighting an anatomy assessment has within the overall assessment scheme, leads to increased motivation to learn anatomy. Similarly, a recent study within the same medical program as the current study found that students only started engaging with a social media site, which had been integrated into their curricula to provide additional support, when the high-stakes assessment approached (Pickering and Bickerdike, 2016). Furthermore, this study highlighted that within this cohort it was observed that many students were still unaware of some key learning objectives that were required as part of the assessment even though these had been made available at the beginning of the course. The findings from these studies from within the anatomy education discipline, may point to a more nuanced assessment of the drivers that lead to meaningful engagement with learning resources. Against this backdrop it can be observed that although TEL resources can play an important role in supporting the acquisition of knowledge, concepts and skills, for the latest generation of students, their adoption and integration should be done so with the necessary caution.

An alternative driver that can lead students to engage with TEL resources to support their learning is motivation, with Pizzimenti and Axelson (2015) concluding that specific elements of motivation (e.g., 'intrinsic goal setting', 'task value', 'control of beliefs', and 'self-efficacy') positively correlate with assessment outcomes. Given the inability of engagement, as defined and determined within this study, to serve as a predictor for assessment outcomes, its continued focus may continue to provide information of the how, but fail to understand the why. In fact, a more likely scenario would be that the specific features of the course's assessment scheme, in combination with and an individuals' own motivation and goals for undertaking a specific program, may account for the inherent drive to utilize the available learning resources to support their learning.

Future Directions

This study has provided clear insights into how students engage with TEL resources as part of an anatomy program that contains a high-stakes spotter style assessment, with three emergent factors describing student behavior. However, the study has not provided clear indications as to the impact different levels of engagement have on assessment outcomes, or that varying levels of engagement exist across a cohort of students. Given the study's findings, it would be interesting to observe changes in engagement with TEL under varying conditions that include the same learning objectives, but assessed in a more informal low-stakes environment, and to also further explore students motivation to learn anatomy within different programs (i.e., medicine and/or dentistry versus pure anatomy/biomedicine) as the engagement with material when the assessment is of a low-stakes nature and motivation is the single dominant factor in determining levels of engagement. Finally, more work on the underlying role of engagement as a social construct and its impact on learning gain as a suitable and reliable proxy for learning should be attempted. By reviewing and expanding the items contained with the TEL engagement scale, expanding the levels of engagement to be inclusive of all TEL resources with the anatomy program, and to continually explore the links to assessment, this important area of pedagogical research can continue to support the development of robust anatomy curricula.

Limitations of the Study

The development and utilization of self-report instruments allows data from large cohorts of students to be collected and with suitable methodologies attempts can be made to draw out the underlying self-perceived behaviors across the sample population (Chan, 2009). By combining these data with fixed variables such as resource usage and assessment outcomes, potential links between certain behaviors and future performance can be explored. However, a cautionary note should be added as notwithstanding the rich and plentiful feedback collected via this methodology, asking participants to accurately comment on their own behavior can be prone to error, with participants often over-estimating their behavior (Kruger and Dunning, 1999; Jamieson-Noel and Winne, 2002). Moreover, the level of usage with TEL resources is also a limitation as, again, this is relying on the student's own perceptions of usage and is not a quantifiable metric such that could be obtained from an online database or repository. However, the number of downloads a particular student completes with a specific resource does not provide information on the total length of time exposed to that resource and if a single resource, such as the iBook, was downloaded on to a tablet device, there is no way of knowing whether that resource was used at all or a large number of times.

This study has attempted to define and then measure engagement as determined by the items originally used within the TEL engagement scale, and then inferred after both statistical and subjective approaches. The description of engagement is therefore limited to those specific items used. It is unknown if additional or alternative items used in the original scale would have yielded different factors and whether the same levels of engagement would have been observed. Furthermore, it is difficult to accurately correlate a specific construct at one point in time with the outcomes of an assessment that was held previously. The actual behavior of highly motivated medical students, as in this study, is likely to be different in the build up to an assessment compared to their attitudes and self-perceived behaviors afterwards. A clear limitation, therefore, of this study is the to assume that the levels of 'engagement' detailed by the student are an accurate reflection of their in-course behavior.

CONCLUSIONS

This study attempted to define the patterns of engagement with TEL resources and to assess any potential links with assessment outcomes. Although no links between student engagement and learning outcomes were discerned, the patterns of engagement with TEL resources were determined. Although engagement with TEL resources that form part of an anatomy curriculum is an important factor in student learning, given the lack of substantial evidence to support the conflation of engagement with an enhancement of learning outcomes, the introduction of TEL resources into curricula as a proxy to support learning should be conducted with caution. Given the methodologies available to assess the efficiency and effectiveness of a TEL resource on learning gain, these metrics should perhaps be a more determining factor in introducing TEL into anatomy curricula.

ACKNOWLEDGEMENTS

The authors wish to express thanks to Dr. Jennifer Hallam for advice on the methodology used throughout this study, and also the reviewers and editors for their supportive and constructive feedback received on this manuscript.

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TABLES

Table 1. Rotated component matrix after Principle Component Analysis of the final 19 item technology-enhanced learning (TEL) engagement instrument.

Item No.	Item	Factor		
		Factor 1	**Factor 2**	**Factor 3**
		Satisfaction	**Goal setting and Planning**	**Physical Interaction**
1	I enjoy using a range of TEL resources	0.804		
24	I heavily engage with the TEL resources	0.754		
20	I like using TEL resources	0.729		
25	I look forward to using the TEL resources on my course	0.712		
6	I actively seek TEL resources to support my learning	0.633		
2	I spend sufficient time with TEL resources	0.521		
15	I use TEL resources to consolidate and revise after class	0.520		
10	I use TEL resources to help me achieve my learning goals	0.513		
13	I set myself goals before I learn with TEL resources		0.749	
9	I plan ahead to incorporate my TEL resource use		0.677	
21	I plan my learning when using the TEL resource		0.576	
12	I complete all TEL tasks that I start		0.516	
14	I use TEL resources to prepare for class		0.513	
16	I think about what I have learnt after engaging in the TEL resource		0.488	0.432*
11	I link what I already know to the TEL resource		0.415	
22	I make notes when using the TEL resource			0.755
17	I carefully listen when using TEL resources			0.682
19	I go over the TEL resource in detail			0.629
23	I return to TEL resources if I still don't understand the subject			0.603

Varimax (orthogonal) rotation with Kaiser normalization; rotation converged in 5 iterations; 47.71% total variation explained; *cross-loading item.

Table 2. Spearman correlations to test for the inter-factor relationships within the technology-enhanced learning engagement scale**.**

	Factor 1	**Factor 2**	**Factor 3**
Factor 1	1	0.47[a]	0.48[a]
Factor 2		1	0.54[a]
Factor 3			1

[a]P < 0.001; Factor 1, Satisfaction; Factor 2, Goal setting and planning; Factor 3, Physical interaction.

Table 3. Overall technology-enhanced learning engagement and individual factors for female and male medical students.

Factors	**Gender**					
	Female		**Male**		**Mann-Whitney U**	
	Median (±SD)	**n**	**Median (±SD)**	**n**	**U**	**P-value**
Factors 1-3	75.0 (±9.3)	112	74.0 (±9.7)	67	3661.5	0.787
Factor 1	34.0 (±4.8)	120	34.0 (±5.2)	70	4035.0	0.651
Factor 2	23.0 (±4.5)	116	24.0 (±4.1)	68	3789.0	0.656
Factor 3	21.0 (±2.6	116	22.0 (±3.1)	69	3928.0	0.832

Factors 1-3, Overall engagement in technology-enhanced learning score; Factor 1, Satisfaction score; Factor 2, Goal setting and planning score; Factor 3, Physical interaction score; ±SD, standard deviation; U, Independent Mann-Whitney U test; P, significance level.

Table 4.
Overall technology-enhanced learning resource engagement and individual factor scores for varying levels of usage.

TEL resource	Scale/Sub-scale	Used a lot		Used sometimes		Used a little		Total		Independent samples Kruskal-Wallis H test		
		Median (±SD)	**n**	**Median (±SD)**	**n**	**Median (±SD)**	**n**	**Median (±SD)**	**n**	χ^2	**df**	**P-value**
MOOC	Factors 1-3	79.0 (±7.2)	23	75.0 (±7.8)	18	75.0 (±7.8)	30	76.0 (±7.8)	71	5.148	2	0.076
	Factor 1	37.0 (±3.2)	26	36.0 (±3.3)	18	35.0 (±3.2)	32	36.0 (±3.3)	76	9.387	2	0.009[a]
	Factor 2	25.0 (±4.6)	25	23.5 (±4.0)	18	22.0 (±4.4)	31	23.5 (±4.4)	74	4.203	2	0.122
	Factor 3	21.5 (±2.3)	24	21.0 (±2.4)	18	21.0 (±2.7)	31	21.0 (±2.5)	73	0.135	2	0.935
iBook	Factors 1-3	76.0 (±7.8)	57	75.5 (±7.5)	40	72.0 (±9.9)	41	75.0 (±8.5)	138	6.051	2	0.049[b]
	Factor 1	35.0 (±4.1)	65	35.0 (±3.6)	40	33.0 (±5.2)	42	35.0 (±4.4)	146	5.310	2	0.070
	Factor 2	23.0 (±4.1)	61	24.0 (±4.1)	40	22.0 (±4.4)	42	23.0 (±4.2)	143	4.699	2	0.095
	Factor 3	22.0 (±2.4)	61	22.0 (±2.2)	40	21.0 (±3.1)	41	22.0 (±2.6)	142	0.323	2	0.851
YouTube	Factors 1-3	76.0 (±8.3)	149	69.0 (±9.6)	22	59.5 (±13.5)	8	75.0 (±9.3)	179	15.285	2	0.000[c]
	Factor 1	35.0 (±4.4)	158	30.5 (±4.7)	24	25.5 (±7.0)	8	34.0 (±4.9)	190	23.057	2	0.000[d]
	Factor 2	23.0 (±4.2)	153	24.0 (±4.7)	23	19.5 (±5.0)	8	23.0 (±4.3)	184	4.943	2	0.084
	Factor 3	22.0 (±2.5)	154	20.0 (±2.9)	23	19.0 (±3.5)	8	21.0 (±2.7)	185	11.903	2	0.003[e]

Factors 1-3, Overall engagement in technology-enhanced learning score; Factor 1, Satisfaction score; Factor 2, Goal setting and planning score; Factor 3, Physical interaction score; ±SD, standard deviation; n, sample size; χ^2, Kruskal-Wallis H; df, degrees of freedom; P, significance level; MOOC, Massive Open Online Course. Specific post-hoc pairwise comparison for factors and TEL usage are indicated by hyperscript (a-e).
[a]Factor 1: Used a lot vs Used a little P = 0.007; [b]Factor 1-3: Used a lot vs Used a little P = 0.051; [c]Factor 1-3: Used a lot vs Used a little P = 0.013, Used a lot vs Used sometimes P < 0.011; [d]Factor 1: Used a lot vs Used sometimes P < 0.001, Used a lot vs Used a little P = 0.015; [e]Factor 3: Used a lot vs Used sometimes P = 0.019.

FIGURE LEGENDS

FIGURE 1

Quantitative data obtained from the technology-enhanced learning engagement survey that details the levels of usage for each technology-enhanced learning resource displayed in a bar chart. Level of usage: used a little, white; used sometimes, red; used a lot, blue; TEL, technology-enhanced learning; $n = 192$; $^{a}P < 0.001$.