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ORIGINAL RESEARCH ARTICLE

Content-specific differences in Padlet perception for collaborative learning amongst undergraduate students

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Collaborative learning offers benefits but there is insufficient information on how students perceive specific digital tools supporting collaborative learning and whether there are content-related differences in students' perceptions. Here, we utilised Padlet to mediate collaborative learning amongst undergraduate students from two distinct disciplines, Dentistry and Bioscience to examine students' perceptions of Padlet-mediated learning and identify any content-specific differences. Data distribution was assessed via Shapiro–Wilk test, Mann–Whitney U test was used to assess distribution of responses and correlations were studied via Spearman's rank correlation coefficient (ρ). Data revealed that majority of students across both cohorts perceived Padlet as easy to use and beneficial to learning. Dentistry students perceived Padlet to be more beneficial to learning and easier to use than Bioscience students ($p < 0.01$). Most Bioscience students liked to undertake collaborative learning via Padlet, whereas most Dentistry students felt more confident to ask questions and better understood content via Padlet. In the Bioscience cohort, perceived benefit-to-learning strongly correlated ($\rho = 0.75$; $p < 0.01$) with fondness to use Padlet, whereas in the Dentistry cohort, it moderately correlated ($\rho = 0.5$; $p < 0.01$) with better understanding of subject content. Thematic analysis of students' textual responses revealed anonymity, peer-learning and engagement as key benefits. Thus, this study strengthened the evidence for using Padlet for collaborative learning in a wider context. Moreover, it uncovered significant disparities in students' perceptions of the tool, when used to foster learning of different subject contents.

Keywords: bioscience education; collaborative learning; dental education; Padlet; student engagement

To access the supplementary material, please visit the article landing page

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Introduction

Active learning enhances students' performances across disciplines (Freeman *et al.*, 2014). It is achieved through active participation of students in the learning process, which not only improves academic success but also increases student satisfaction, motivation and well-being (Bernard, 2015). However, even when active learning is achieved during teaching sessions, there can be variability in the levels of benefits imparted to the students. Often, only a few students participate in the activity or vocalise their thoughts, thereby engaging better and gaining more learning benefits than others. Diminished student engagement impedes achievement of excellence, particularly in large courses (Young and Nichols, 2017). Therefore, it is essential to use educational tools that not only promote active learning but also provide equal opportunities to all in terms of engagement.

The current shifts in education have created an environment where learning is no longer restricted as an individualistic activity. Collaborative active learning, a branch of connectivism, is a well-established pedagogical approach that offers various advantages to the students including acquisition of new knowledge (Bravo *et al.*, 2018), self-regulatory behaviour, student autonomy and positive interdependence (Scager *et al.*, 2016). It is one of the educational approaches used to achieve active learning by engagement. Collaboration creates an effective learning environment by creating learning relationships (Cotterill, 2015) and has shown to offer benefits such as student engagement while supporting learning across different disciplines (Donaldson *et al.*, 2017; Jackson, Bilich, and Skuza, 2018; Laal and Ghodsi, 2012; Sahota *et al.*, 2016; Zhang and Cui, 2018) or increasing efficacy in exam performance (Duret *et al.*, 2018). Several digital tools have shown to foster student engagement through a collaborative experience. For instance, digital tools including MediaWiki and Google Docs have been used by Information Management students to efficiently co-construct knowledge (Chu and Kennedy, 2011) while iPads have enhanced collaborative learning in tutorial sessions of physics students (van der Ventel *et al.*, 2016) and stimulated engagement of nursing students with learning activities and materials (Davies, 2014). In yet another example, online lectures, WebCT communication tools and video case studies have been used by BA social work students to develop their reflective skills to enable working with diverse communities (Cooner, 2010).

Padlet (padlet.com) is an interactive platform used for collaborative learning. It is a web-based tool that creates an online virtual wall, a pin board on which multimedia content can be posted. These may include documents, questions, comments, images, videos and audio clips, which the students can access any time. Although Padlet has demonstrated its usefulness in engaging students for collaborative work (DeWitt, Alias, and Siraj, 2015; Rashid, Yunus, and Wahi, 2019; Zhi and Su, 2015), there is insufficient information on how students perceive the usage of this tool. Moreover, there is limited evidence of content-specific differences in students' perception of Padlet-mediated learning. While a whole range of other digital tools in a post Web 2.0 era have been explored to some extent (Brodahl, Hadjerrouit, and Hansen, 2011; James and Figaro-Henry, 2017; Lee *et al.*, 2020), there were a number of reasons for studying this specific digital tool. For example, in comparison to a Virtual learning environment (VLE) such as Moodle that may require technical skills to set up or a collaborative wiki (more suited to online learning) or an audience response system (more suited to group responses but not collaboration), Padlet allows for immediate collaboration that can take place in blended format, both on campus and online. In

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addition, here, Padlet usage was studied due to its novelty to the university to examine whether it would work well in this institutional context.

Students' perceptions of a digital tool are important in determining their acceptance of the tool and their engagement in learning (Venkatesh, 2000; Venkatesh and Davis, 2000; Taylor and Todd, 1995). These perceptions become even more important when the learning is via online sessions, as is in this pandemic era and in regular distance learning courses. Accordingly, student perceptions of active online practices (Koohang *et al.*, 2014) and students' perceptions of classroom climate in an online learning environment have been investigated (Kaufmann, Sellnow, and Frisby, 2016), and these perceptions have been thought to be important predictors of student engagement when delivering online education (Cole, Lennon, and Weber, 2019). Therefore, it is important to understand students' viewpoints on a digital tool for successful teaching and learning. Moreover, from an academic's perspective, it can be difficult to gauge the level of student engagement when providing online education, unlike in case of face-to-face teaching sessions. Knowledge of student engagement can greatly help the academic to devise measures that facilitate enhanced quality learning. This study not only examined students' perception of Padlet usage but also provided the academics with a means to gauge student engagement, when delivering online or face-to-face teaching sessions.

Accordingly, here, we report a study carried out amongst students of two distinct disciplines, Dentistry and Bioscience to compare students' perceptions of using Padlet as a tool for collaborative learning. This approach is innovative in the sense that it relates a specific digital tool (Padlet) to the content-specific context of Bioscience and Dentistry and assesses contextual pedagogical challenges and benefits. Since students' perception of a tool can influence their engagement with a topic, we aimed to understand student's perceptions of Padlet usage for collaborative learning. We also aimed to check whether their perceptions varied with teaching content – in our case, biological and mathematical.

Rationale

Presently, there are limited methods/tools available that would help students co-create work, make contributions and ask questions anonymously, and resolve questions in a collaborative manner without the fear of being judged. Padlet can fulfil these requirements and, therefore, further exploration of its usage in a content-specific context of Bioscience and Dentistry would extend its applicability. Moreover, the coronavirus disease 2019 (COVID-19) pandemic has had a knock-on effect on the education sector. In the forthcoming period, engaging students will be challenging as higher education institutions plan to drastically reduce face-to-face teaching and increase remote teaching. This calls for increased usage of digital tools to fully meet the learning outcomes. Also, since students' attitudes towards a digital education tool can determine their engagement and the success of a teaching and learning experience, it would be extremely useful to examine their responses to Padlet-mediated collaborative learning. This would not only help to better understand their perception of learning via digital tools and recognise any content-specific patterns in perceptions but also help in acquiring and retaining maximum student engagement while working remotely during the pandemic period and beyond. These aspects collectively underscore the value and importance of this research.

Methods

Participants

Students (total $n = 57$) from two distinct cohorts belonging to different disciplines, Biosciences (Year 1, $n = 34$) and Dentistry (BDS1 Year 1, $n = 23$) from undergraduate level at King's College London (UK) participated in this study. The Bioscience students in this study were mainly those undertaking the same Physiology module. Ethical approval was obtained from King's College London (UK) ethics committee in advance and granted under the ethics committee approval number MRA-19/20-17125. All participating students were verbally informed about the study and its purpose at the start of every session and prior to obtaining their responses. Information about the study was also included on the online Google forms on which students' responses were to be obtained.

Protocol

Using an experimental licenced version of Padlet, the involved academics designed topic-specific Padlet walls, shortened the links to the walls at https://tinyurl.com/ and provided these to the students prior to each teaching session. These virtual walls with pre-stated session-specific subtopics or questions provided a platform for the students and the academics to post questions, comments and multimedia content under the corresponding subtopic. Provision of multiple subtopics on each Padlet wall (distinct for each session) by the academic provided a definite direction for the students and the academics to work on. At the beginning of every session, the pedagogical purpose of using the Padlet was discussed with the students, the students were informed about its features, taught how to use it and how to post information on the virtual wall. Students were informed about the expectations from them, that is, activities they needed to undertake including posting content, questions and comments in response to the pre-stated subtopic or question on the virtual walls. They were also informed that the Padlet walls would remain active throughout the term and up to the assessment period so that all students could gain access to it and continue interacting with the academic and their peers to prepare for exams. Through Padlet, while the Dentistry students were taught subject-specific biological concepts, sessions of the Bioscience students predominantly covered topics that involved mathematical formulae and calculations relating to human physiological concepts. At the end of every teaching session, the students were encouraged to respond to a set of predesigned statements (on a Likert-type scale, explained in the succeeding section) that intended to understand the effect of using Padlet on learning and its benefits as a tool for collaborative teaching and learning, as perceived by the students. Responses were obtained from both the student cohorts and analysed thematically and statistically.

Questionnaire

The questionnaire statements were designed using Google forms (Online resource). These contained a set of five statements, and for each statement there was a range of response options to choose from a 5-point Likert-type scale: disagree, strongly disagree, neutral, agree and strongly agree. Both Biosciences and Dentistry cohort questionnaires included the statements 'I felt this tool was beneficial to

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my learning' and 'I felt this tool was easy to use'. Thus, these important questions about Padlet – one addressing perceived benefit to learning and another on perceived ease of usage, were asked to both cohorts. In addition, while the Bioscience students' questionnaire included 'I liked to do collaborative learning with my peers using Padlet', the Dentistry students' questionnaire included 'I felt confident to ask questions on Padlet' and 'I better understand lecture content through Padlet'. Students' ratings (responses) to these statements were collated and subjected to statistical analysis. Questions asked to Dentistry and Biosciences students diverged to reflect differences in the teaching activities undertaken using Padlet walls in the two disciplines. While Biosciences students engaged through Padlet during small group tutorial sessions to share and discuss answers to pre-set questions, Dentistry students used Padlet walls during and after lectures delivered to the whole cohort, as a platform where students could ask questions on the content delivered and answer peers questions. This variability enabled us to get a better overview of students' responses and understand the effect of Padlet usage in different learning environments and help relate the results to a wider setting. Questionnaires of both cohorts included an additional statement 'Any other comments on this tool', where the students were requested to respond in an open-ended manner, and the responses were subjected to thematic analysis. This provided them with an opportunity to be reflective and write textual responses and opinions to comment on any other aspect that was not included in the preceding set of Likert-type scale responses. This type of questionnaire was used because it allowed the students to respond easily, quickly and it effectively addressed the aim of this study, which was to understand students' perceptions' of using Padlet for learning, as indicated by the questions in the questionnaire

Data analysis

The obtained Likert-type scale responses were transformed into numerical values (strongly disagree/disagree = 0, neutral = 1, agree = 2 and strongly agree = 3). Since there were very few responses as 'strongly disagree' and 'disagree', these were combined and presented as one unit. Data were analysed using IBM SPSS statistics software version 26. Data distribution was assessed via Shapiro–Wilk test, which revealed that the data were not distributed normally. Therefore, Mann–Whitney U test was used to assess the distribution of responses. Data were expressed as median with interquartile range and 95% confidence intervals. Correlations were studied via Spearman's rank correlation coefficient (ρ). A correlation was considered negligible if the coefficient lay between 0 and 0.3 (or 0 and −0.3), weak between 0.3 and 0.5 (or −0.3 and −0.5), moderate between 0.5 and 0.7 (or −0.5 and −0.7) and strong between 0.7 and 1 (or −0.7 and −1) (Mukaka, 2012). Responses to the open-ended question were analysed via thematic analysis, as previously described (Braun and Clarke, 2006, 2014) encompassing a six-stage process; familiarisation, coding, theme extraction, review, naming and narrative analysis (Braun and Clarke, 2014; Persson *et al.*, 2017). Quotes have been provided as validity of evidence (Mays and Pope, 1995). Punctuation was added to unambiguous quotes and spelling mistakes were corrected. Multiple quotes from one person were treated as a single comment to avoid over-representation of an individual. Results of the statistical analysis were considered jointly with those of thematic analysis while drawing conclusions and to obtain a holistic view of quantitative and qualitative data.

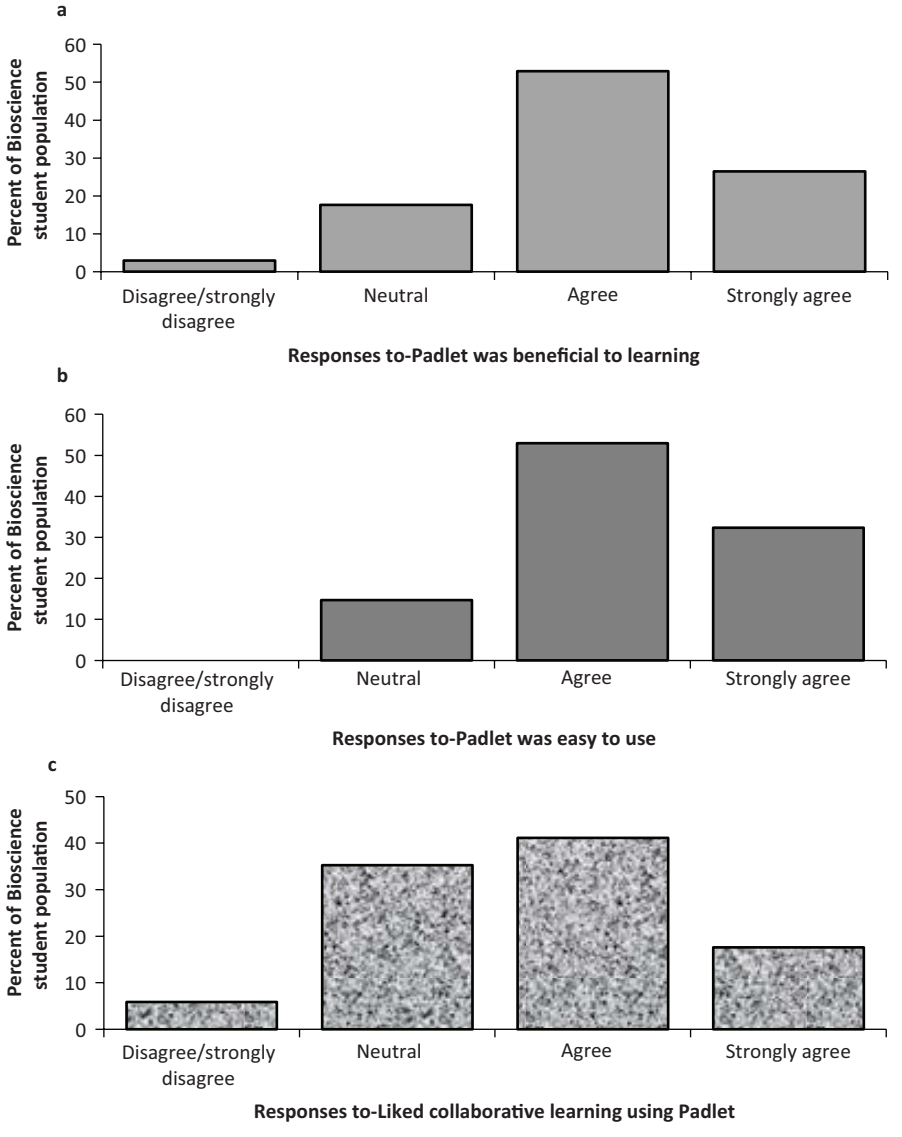

Figure 1. Responses of the Bioscience student cohorts. (a) Student responses to whether they found Padlet as a beneficial tool to aid learning. (b) Student responses to whether they found Padlet easy to use. (c) Student responses to whether they liked to do collaborative learning through Padlet.

Results

Bioscience cohort

Majority of students from the Bioscience cohort (approximately 80%) either agreed or strongly agreed that the usage of Padlet was beneficial to their learning (Figure 1a). A total of 85% students felt that Padlet was easy to use (Figure 1b) and 59% felt that they liked to undertake collaborative learning via Padlet (Figure 1c). Approximately, 1/3rd of the students remained neutral to collaborative learning via Padlet (Figure 1c).

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A small percentage of students (3%–6%) disagreed that using Padlet was beneficial to their learning (Figure 1a) and their choice of responses on the Likert-scale implied that they did not like to undertake collaborative learning using Padlet (Figure 1c).

Dentistry students

All students of Dentistry (100%) responded in favour of Padlet being beneficial to their learning and voted it as an easy-to-use tool (Figure 2a and b). In addition, 91% of students either agreed or strongly agreed as they felt more confident to ask questions on Padlet (Figure 2c), and 87% of students agreed or strongly agreed as they better understood the lecture content with the aid of Padlet (Figure 2d). None of the student responses from the Dentistry cohort stated that Padlet was not beneficial to learning (Figure 2a), was not easy to use (Figure 2b) and that it did not mediate better understanding of the lecture content (Figure 2d).

Comparison of responses between Bioscience and Dentistry cohorts

Next, we investigated whether the two student cohorts differed based on their responses to the parameters – Padlet being beneficial to their learning and its ease of use. Data revealed that the distribution of responses in the Dentistry students

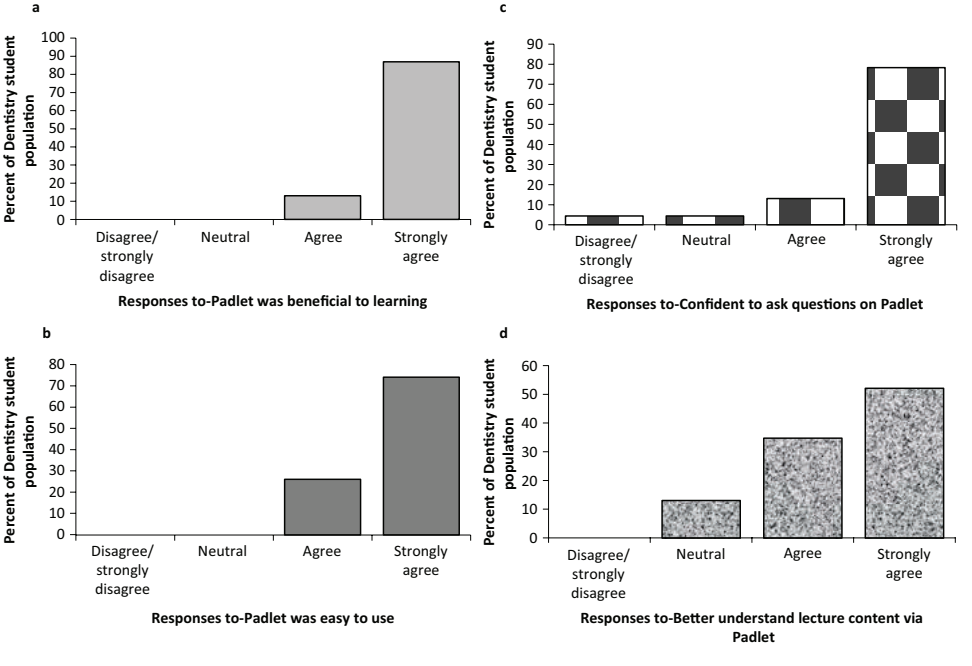

Figure 2. Responses of the Dentistry student cohort. (a) Student responses to whether they found Padlet as a beneficial tool to aid learning. (b) Student responses to whether they found Padlet easy to use. (c) Student responses to whether they were confident to ask subject-related questions on Padlet. (d) Student responses to whether they thought they could better understand the lecture content due to the usage of Padlet.

was significantly higher than that in the Bioscience group for both these parameters ($p < 0.01$) (Figure 3a and b) (Supplementary File).

Correlation between parameters across cohorts

The ease of using a teaching and learning tool can be an important determinant of its perceived benefits to learning both by the students and the academics. Therefore, we examined whether there was a correlation between these parameters within each student cohort. Data showed no correlation between the ease of using Padlet and the perceived benefit of learning across the two student cohorts (Tables 1 and 2). However, the Bioscience student group showed a borderline moderate positive and significant correlation between the ease of using Padlet and undertaking collaborative learning using Padlet (Table 1, $\rho = 0.47$; $p < 0.01$). Also, this group showed a strong positive and significant correlation between their liking to undertake collaborative learning via Padlet and Padlet being beneficial to their learning (Table 1, $\rho = 0.75$; $p < 0.01$). The correlations between these parameters in the Bioscience cohort is graphically depicted

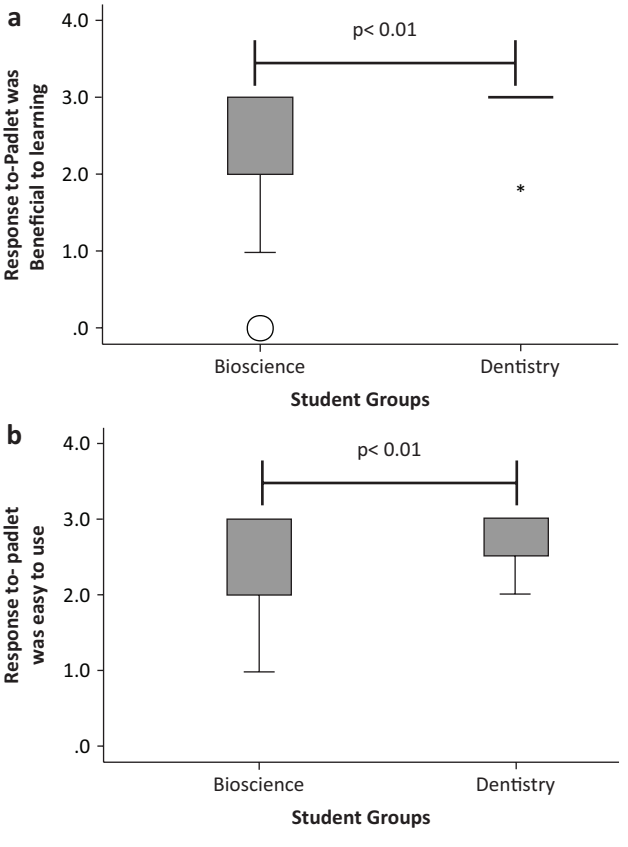

Figure 3. Distribution of responses between the Bioscience and Dentistry student cohorts. (a) Distribution of responses to whether the students found the usage of Padlet beneficial to learning. (b) Distribution of responses to whether the students found Padlet easy to use. Circle and star represent outliers.

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in Figure 4. No significant correlations were observed between these parameters in the Dentistry cohort (Table 2), except a moderate positive correlation between understanding the lecture content via Padlet and their perceived benefit to learning due to Padlet (Table 2, $\rho = 0.5$; $p < 0.01$).

Thematic analysis of textual responses

All student responses to the open-ended question in the questionnaire were thematically analysed. Key themes emerged, which related to visual presentation, educational benefit, engagement, anonymity and collaboration. These have been tabulated in Table 3.

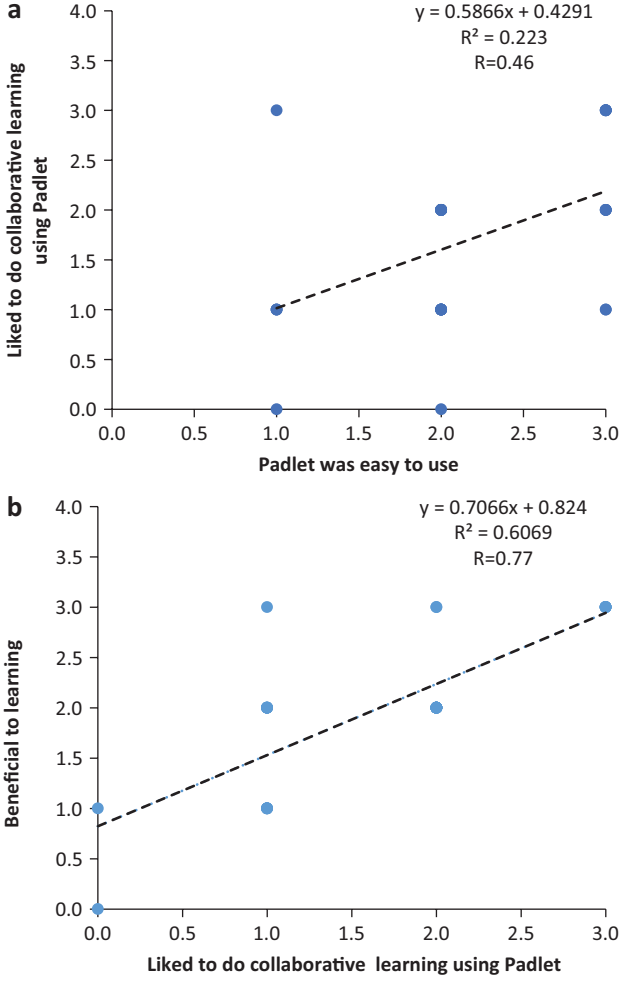

Figure 4. Correlations between parameters in the Bioscience cohort. (a) Correlation between student responses to 'Like to undertake collaborative learning with Padlet' and responses to 'Padlet was easy to use'. (b) Correlation between student responses to 'Like to undertake collaborative learning with Padlet' and perceived benefit to learning. The Correlation coefficient R is the square root of the value of R^2 shown in the figures.

Table 1. Correlations of parameters in the Bioscience student cohort.

Correlations (Bioscience Student groups)			Beneficial .to. learning	Padlet. was.easy. to.use	Liked.to. do. collaborat ive. learning, using. Padlet
Spearman's rho	Beneficial.to. learning	Correlation Coefficient	1.000	0.277	0.751"
		Sig. (2-tailed)		0.113	0.000
		N	34	34	34
	Padlet.was.easy. to.use	Correlation Coefficient	0.277	1.000	0.476"
		Sig. (2-tailed)	0.113		0.004
		N	34	34	34
	Liked.to.do. collaborative. "g-using-	Correlation Coefficient	0.751"	0.476"	1.000
		Sig. (2-tailed)	0.000	0.004	
		N	34	34	34

**.Correlation is significant at the 0.01 level (2-tailed).

Table 2. Correlations of parameters in the Dentistry student cohort.

Correlations (Dentistry student groups)			Beneficial .to. learning	Padlet. was.easy. to.use	Confident .to.ask. questions .on.Padlet	Better, understa nd. lectures. via.Padlet
Spearman's rho	Beneficial.to. learning	Correlation Coefficient	1.000	0.064	0.081	0.547"
		Sig. (2-tailed)		0.772	0.713	0.007
		N	23	23	23	23
	Padlet.was.easy. to.use	Correlation Coefficient	0.064	1.000	0.166	0.084
		Sig. (2-tailed)	0.772	0.0	0.450	0.703
		N	23	23	23	23
	Confident. to.ask. questions.on. Padlet	Correlation Coefficient	0.081	0.166	1.000	0.200
		Sig. (2-tailed)	0.713	0.450	0.0	0.359
		N	23	23	23	23
	Better, understand. lectures.via. Padlet	Correlation Coefficient	0.547"	0.084	0.200	1.000
		Sig. (2-tailed)	0.007	0.703	0.359	0.0
		N	23	23	23	23

** .Correlation is significant at the 0.01 level (2-tailed).

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Table 3. Thematic analysis of qualitative (open-ended) textual responses.

Theme	Feature	Comments from students
General benefits in terms of increased engagement	Several students were positive about the tool in terms of how it made them feel more engaged	• 'Really good idea, love the question panel!' • 'This is a great resource to have' • 'I would hesitate more to ask a question via email but the Padlet allows me to comfortably ask anything I am unsure about. It is also nice to see what other people have asked in order to reinforce my own understanding. It would be really great if this could be offered for all lectures!'.
Benefits of anonymity	Several students felt that the ability to respond anonymously was beneficial	• 'Love the anonymous question panel. Would be great to have this for BMS too!' • 'I like the ability to ask anonymous questions.
Benefits of collaboration – peer learning	A few students mentioned that being able to review their peers' questions and work collaboratively was of benefit	• 'It also enables you to learn from other students' questions that you would not have thought of to ask'.
Technical or pedagogical challenges	There were some technical challenges like the fact staff and student comments were not clearly delineated	• 'If possible, it would be good to know which answers the tutor's and which ones are my peers'. • Other comments arguing that the lecturer is the most important factor: 'The presenter is important not the tool'.
Visual presentation	Students found Padlet visually appealing	• 'Students have told me that visually it is something that they like, they find it engaging, and they like to use it. It could be used in different settings, including for personal tutorials'.

Discussion

We evaluated students' responses on the usage of Padlet as a tool for collaborative learning. Participating students were from two distinct cohorts, Bioscience and Dentistry. The aim of this study was to understand how students perceived the usage of this tool for collaborative learning and identify any content-specific patterns in their perceptions.

The choice of disciplines was a serendipitous event and reflects the disciplines of the academics interested in conducting this study. Regardless, this offered several advantages that better fulfilled the aim of the study. Firstly, it enabled examination of the perceptions of students in two distinct disciplines. Secondly, it helped

evaluate students' perceptions of Padlet usage while learning different types of subject content – biological and mathematical. Moreover, based on their respective teaching experiences, the involved academics hailing from different disciplines had felt the need to increase and improve student engagement during and after in-person teaching sessions. The usage of Padlet provided a perfect means to promote the engagement of students with the subject content, with each other (for collaborative learning) and with the academic.

Data revealed that a great majority of the students across both cohorts felt that Padlet was beneficial to their learning (Figures 1a and 2b) and it was easy to use (Figures 1b and 2b). Responses implied that most Bioscience students liked to undertake collaborative learning via Padlet (Figure 1c), while most Dentistry students felt confident to ask questions using Padlet (Figure 2c) and better understood lecture content through Padlet (Figure 2d). This was reflected in the responses to the thematic open-ended question, which resonated the positives of anonymity while posting data and responding to questions (Table 3). Also, transparency of the questions and comments between students was thought to reinforce understanding; all collectively kindling the notion that Padlet was beneficial to their learning. The combined results of statistical and thematic data analysis implied that this approach enhanced student engagement and most students showed a positive inclination towards using this tool for collaborative learning. Thus, the successful utilisation of Padlet in this study further strengthened the evidence base on this approach for digital team-based learning and matched other studies where this tool transformed student engagement in seminars (Garnham and Betts, 2018), helped achieve high level of satisfaction and academic performance (Beltrán-Martín, 2019) and aided in conceptual understanding of social studies (Baildon, Lin, and Chia, 2016).

A significant difference in student perceptions was observed between the two cohorts on the ease of using Padlet. The distribution of responses in the Dentistry cohort was significantly higher than the Bioscience cohort (Figure 3b), which implied a more positive feedback on ease of use by the Dentistry students. This may be partly attributed to the differences in the topics taught. While the Padlet walls for the Dentistry cohort mediated learning of non-mathematical biological concepts, walls used for the Bioscience cohorts largely facilitated physiology-based problem-solving workshops involving mathematical formulae and calculations. During the Bioscience sessions, it was observed that the students struggled to type complex mathematical formulae (involving multiple brackets and intricate mathematical relationships between numbers and letters) on the Padlet's posting bar. The difficulty in typing the mathematical formulae on the wall could have led to this tool being perceived as less easy to use than that perceived by the Dentistry students. In turn, this may have influenced their perceived benefit of Padlet-mediated learning resulting in a comparatively lower distribution of responses than the Dentistry cohort (Figure 3a). This demonstrated content-specific differences in students' perceptions of the same tool. Also, this clearly indicated that the topics covered using this tool can modulate the type and range of student responses and guide students' perceptions of learning. Indeed, the successful usage of any tool depends on how it is integrated into the adopted pedagogical approach and the related teaching and learning activities.

If both student cohorts were undertaking the same module (content), then that would have helped in drawing direct comparisons of discipline-specific perceptions. However, this would have prevented the understanding of the effect of differing

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subject content on the perceptions of tool usage. Here, the variability in subject content became the strength of the study as it led to an interesting observation that despite the same academic stage (year 1) and tool, students' perceptions varied, and this could be attributed to the differences in subject content.

In choosing and using tools to promote student engagement and collaboration, perceived usefulness and perceived ease of use are the key determinants of students' acceptance of the tool or technology (Taylor and Todd, 1995; Venkatesh, 2000; Venkatesh and Davis, 2000). Based on this, we expected a strong positive correlation between the two parameters- ease of use and Padlet being considered as beneficial to learning. Contrasting the hypothesis, no significant correlation was observed between these parameters across both cohorts in this study (Tables 1 and 2). Instead, in the Bioscience cohort, the ease of using the tool positively correlated with their fondness (liking) to undertake collaborative learning using Padlet (Table 1) (Figure 4a). This is logically acceptable because if a tool is perceived as easy to use, the participants will be inclined to undertake learning using that tool. In the same Bioscience group, the parameter of liking (fondness) to undertake collaborative learning via Padlet strongly and positively correlated with their perceived benefit of Padlet-mediated learning (Table 1) (Figure 4b). This introduces an additional determinant of students' perception of tool-induced benefit to learning, which is, their liking, that is, fondness to use the tool for collaborative learning; in this case the tool being Padlet. Unlike the Bioscience cohort, the Dentistry cohort showed only one significant correlation, which was between the parameters Padlet-mediated benefit to learning and better understanding of lectures through Padlet (Table 2). Since these parameters are interrelated and essentially cover the same principle of learning, this positive correlation, while it undeniably exists, does not introduce an additional determinant of perceived benefits to learning via a digital tool.

In a previous study, student anonymity opened opportunities for discussion, initiated dialogues, increased student participation and promoted student engagement while evading evaluation anxiety (Bergstrom, Harris, and Karahalios, 2011). Similarly, here, utilisation of Padlet as a learning tool that preserves anonymity was well-received by the students (Table 3). This indirectly implied that maintenance of anonymity aided in the learning process in these specific study conditions. Using Padlet provided a means not only to ask questions but also respond to questions anonymously, thereby promoting bilateral communication and enhancing student engagement. While it is important not to amplify these positive perceptions and consider these results as prescriptive or as a 'golden rule', data here and the resultant conclusions can certainly be considered as a good indicator of the overall effect of Padlet-mediated collaborative learning.

Limitations of the study

Amidst the positives, this study posed some challenges and highlighted some limitations. Although the students were happy to use the tool, one of the challenges was to get the students to respond to the survey. Consequently, the number of students using Padlet was far higher than those who responded to the survey, thereby underestimating the true number of participants. In reference to limitations of the tool, the students mentioned that there was no notification mechanism to inform them of a new post on the wall. Also, they felt that the tool would be better if it could distinguish between the academic's and student's posts. Such critique is in line with other studies

where despite the positive perception of Padlet, students in an English remedial class felt that since the students reflected prior to positing, there was delay in the feedback posted and so the discussion on the Padlet was neither natural nor instantaneous (Chuah, 2015). The caveats (and the pros) of online collaborations within health service research networks have also been discussed (Leroy *et al.*, 2017). Like in a previous study where not all students found Padlet to be supportive of learning (Deni and Zainal, 2015), in this study, a small fraction of students responded either 'neutral' or 'disagree' to Padlet-mediated learning benefits and commented that the presenter was more important than the tool. It is important to investigate the reasons for such responses by giving these students an additional opportunity to discuss their opinions in person with the lecturer and/or by encouraging them to describe their opinions in detail in the open-ended question. This would help clarify and better understand the barriers to learning when Padlet-mediated pedagogical approaches are implemented, as also experienced in other studies (Deni and Zainal, 2018; Tammeorg *et al.*, 2019). Thus, the pedagogical approaches need to be exercised with thoughtfulness when using Padlet.

Caution also needs to be exercised when analysing student responses. This is because their responses (particularly to the questionnaire statement on Padlet being beneficial to their learning) reflect their own perception, which may not be a correct and complete indication of whether or how much this tool was beneficial to their learning. Studies have shown that students' perceptions of their learning can differ from reality. For example, when sessions involving passive lectures and active learning with identical course materials were compared, students in the active learning sessions showed a lower perception of learning and felt that they had learnt less, while they had learnt more. This negative correlation was partly attributed to the increased cognitive effort during active learning (Deslauriers *et al.*, 2019). Therefore, it is possible that here, the fraction of Bioscience students that selected 'neutral' or 'disagree' to the statement 'Padlet-induced benefit to learning' (Figure 1a) may have learnt more than what they thought and unknowingly underestimated the benefit to their learning mediated by Padlet. The contextual pedagogical benefits and challenges as perceived by students in the use of Padlet should be taken into consideration when using this platform.

Significance of this research

- For the first time, this approach linked a specific digital tool (Padlet) to the specific context of Bioscience and Dentistry and assessed contextual pedagogical challenges and benefits.
- Peer-learning has shown to impart huge benefits (Keenan, 2014). This research presented a Padlet-mediated mechanism by which peer-learning can be facilitated on a digital platform in these specific disciplines.
- This approach followed the principle of engagement through partnership, as modelled by the Higher Education Academy, which suggests the involvement of students as co-designers and co-developers in the learning process (Higher Education Academy, 2014).
- Since it allowed the students to revisit and review the posted material over a long period of time, it directly resorted to the learning strategy of distributed practice, which is a well-evidenced effective learning technique (Benjamin and Tullis, 2010).

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- Data identified content-related differences in students' perceptions of this tool for collaborative learning, which can improve future Padlet-related collaborative learning activities in these specific disciplines.
- Since the Padlet walls acted as a platform that collated and provided access to different types of resources, it catered to different types of learners under one roof and thereby promoted a holistic and student-centred approach to teaching and learning.
- The approach provided opportunities to the students to pull out of the passive learning/listening mode and actively participate in the learning process via collaboration, thereby adopting participatory learning practices.
- It allowed transition from a transmissive mode of delivery (from lecturer to students) and permitted students to be creators/co-creators of content. Thus, it helped fulfil the institutional goal of 'embracing students as co-creators' of the curriculum.
- This approach could be adopted to improve and retain student engagement during the period of coronavirus pandemic and beyond by facilitating collaborative learning remotely.

It is worth considering the pedagogical approaches that would be suitable for the tool discussed and other similar tools. Notably, active learning can create distractions and therefore, good classroom management is needed when practicing active learning in classrooms. Approaches such as SCALE UP (Foote *et al.*, 2014) may be of use, particularly, the notion of focusing student attention on one active learning approach at a time. This could work in a blended learning approach. While there are several tools that mediate blended learning (Dziuban *et al.*, 2018), Padlet is unique in that it is easy to use and so it helps overcome some pedagogical challenges posed by technologies that foster collaborative learning (Laurillard, 2009) and thereby helps unlock the potential of blended learning (Garrison and Kanuka, 2004). Other approaches that could work well with this tool include a flipped approach where a didactic teaching session is conducted ahead of time and Padlet is used for a subsequent interactive session (Zou and Xie, 2019). Importantly, if collaborative practice is to be implemented, then ensuring that students have the appropriate skills to use the tool can help achieve a productive learning session (Le, Janssen, and Wubbels, 2018).

Practical implications

- Building on previous work related to Padlet (Beltrán-Martín, 2019; Garnham and Betts, 2018), the evidence base on efficacy of this tool has been strengthened.
- We suggest that management in related disciplines consider this as an effective and cost-efficient tool.
- Educators can regard this as a useful tool in their toolkit for both synchronous and asynchronous learning, and for a blended approach – a tool that will easily facilitate collaboration both online and in campus.
- The content-specific differences in student perception combined with the overwhelmingly positive student experience warrant further studies on this topic and in greater depth. A better understanding of content-related differences in students' perception of Padlet as a collaborative tool would enable to provide organisation-wide guidance and support to students and academics to enhance the learning experience.

Future studies

Further studies can be conducted to fully compare responses of students from different disciplines. This can be done by recruiting students who study the same or different topics or undertake different types of laboratory and non-laboratory projects at the same or different academic institutions. Also, studies on Padlet usage can be tested on cohorts that learn via face-to-face teaching and those undertaking purely distance learning courses. Furthermore, it would be interesting to compare students' perceptions on the tool at undergraduate and post-graduate levels. Such studies will give a complete account of the applicability of Padlet and students' opinions on this tool.

Conclusion

For the first time, this approach related a specific digital tool (Padlet) to the specific context of Bioscience and Dentistry and assessed contextual pedagogical challenges and benefits. This not only confirmed the findings of previous Padlet studies in two different groups of students, but also identified potential content-related differences in perceptions. Data distribution was assessed via Shapiro–Wilk test, Mann–Whitney U test was used to assess distribution of responses and correlations were studied via Spearman's rank correlation coefficient.

Students from both disciplines learning different content unanimously perceived Padlet to be beneficial to their learning and easy to use. Dentistry students perceived Padlet to be more beneficial to learning and easier to use than Bioscience students. This could be attributed to the differences in the types of topics covered during the teaching sessions. In the Bioscience group, benefit to learning strongly correlated with fondness for collaborative learning via Padlet, presenting it as an additional determinant of student-perceived benefits to learning. Although thematic analysis of textual responses resonated the perceived benefits, it also highlighted some limitations of this tool. Nonetheless, Padlet proved to be a promising tool for collaborative learning in this content-specific context and the approach promises participatory and distributed practices to achieve active learning through collaboration.

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Conflicts of interest

The authors declare no conflict of interest.

Ethics approval

Ethical approval for this study was obtained from the ethics committee at King's College London, UK (Ethics approval number MRA-19/20-17125).

Notes on contributors

K.J.M collected data, analysed data, prepared manuscript, prepared figures and provided intellectual input. I.M collected data, contributed to manuscript preparation and provided intellectual input. M.D led on original thrust of research, obtained ethical approval, conducted thematic analysis, contributed to manuscript preparation and provided intellectual input.

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