The Role of Technologies to Enhance Pre-service Teachers' Engagement in an Online Mathematics Education Course

Seyum Getenet
University of Southern Queensland
Seyum.Getenet@usq.edu.au

Sue Worsley
University of Southern Queensland
Sue.Worsley@usq.edu.au

Eseta Tualaulelei
University of Southern Queensland
Eseta.Tualaulelei@usq.edu.au

Yosheen Pillay
University of Southern Queensland
Yosheen.Pillay@usq.edu.au

This study reports part of a larger study that explores three technologies—Padlet, video-embedded quizzes and Google docs and their effectiveness for enhancing pre-service teachers' (PSTs) learning engagement in online mathematics education. The data reported in this study are a survey, learning analytics and observation data. We found that Padlet heightened PSTs' social and collaborative engagement, and these dimensions were further enhanced in Google Docs activities. PST's cognitive engagement was enhanced through adding quizzes based on lecture videos. This study contributes to selecting relevant technologies to enhance PSTs' engagement in online learning in general and in mathematics education more specifically.

As learning in higher education is moving more online, this presents a challenge to engage mathematics education students. Various studies showed that technology use in online teaching and learning can improve student engagement (e.g., Attard & Holmes, 2020; Redmond et al., 2018). Accordingly, various interactive technologies are used in online teaching to promote students' engagement and participation in mathematics education. These include online platforms, social media networks, and other digital technologies embedded in university learning management systems. Such technologies can increase students' digital skills, deepen their discipline knowledge and give diverse learners the flexibility to study at their preferred modes of engagement (Lee & Martin, 2020). The current study aimed to improve PSTs' engagement in an online mathematics education course using Padlet, Google docs (GD) and video embedded quizzes. The study used Redmond et al.'s (2018) Online Engagement Framework (OEF) to analyse PSTs engagement in their online learning. This study investigated how embedded technologies enhance PSTs' engagement in an online mathematics education course? Previous studies link technologies to student engagement in general terms; however, this study specifically investigates how PSTs' social, cognitive, behavioural, collaborative, and emotional engagement is enhanced using the selected technologies.

Literature Review

Online Learning, Technologies, and Engagement

Technologies have become central to higher education, affecting all student experience, including engagement. A range of mathematics-specific software are available to provide opportunities for active learning and enhanced student engagement (Attard & Holmes, 2020). As a result, a wide range of technologies have been used in online higher education courses such as Mentimeter, GD, Padlet, and Panapto quiz. In the Australian context, Attard and Holmes (2020) showed that technology used in mathematics education can improve student engagement and increase the number of students wishing to extend their mathematical knowledge. Using a multidimensional view of engagement and the Framework for Engagement with mathematics as a lens, Attard (2018) showed that technologies enhanced students' engagement in learning mathematics. Salvatierra Melgar et al.'s (2021) findings showed that the Mentimeter tool promoted PSTs' engagement in learning mathematics, including

2022. N. Fitzallen, C. Murphy, V. Hatisaru, & N. Maher (Eds.), *Mathematical confluences and journeys* (Proceedings of the 44th Annual Conference of the Mathematics Education Research Group of Australasia, July 3–7), pp. 241–249. Launceston: MERGA.

enhancing their experience and increasing their mathematical knowledge. Suwantarathip and Wichadee (2014) found students' engagement and scores significantly increased by using GD to collaborate on writing assignments compared to those not using GD. Similarly, Ellis (2015) used Padlet to make lessons more interesting by introducing student-generated content and reducing barriers to students contributing to discussions. Ellis's study found that lessons using Padlet were more engaging (83%), posts by other students enhanced students' experience (79%), and students were more likely to contribute to discussion via Padlet than verbally (42%) (Ellis, 2015). Studies have also shown that video-embedded quizzes may reduce online student dissatisfaction and assist with preparing for assessments (Prince, 2016). However, there are limitations to certain technologies. For example, in an exploration of student use of Padlet, Dianati et al. (2020) reported that students considered it easy to use but unwieldy when overpopulated with content. While most of these studies link the technologies to student engagement in general terms, few studies investigated in depth the specific dimensions of engagement that are enhanced and how this occurs.

Students Online Learning Engagement and Indicators

Students' engagement in the traditional learning mode may be limited to activities where they work independently or in small groups to enhance their cognitive engagement. Recent students' engagement has moved away from examining only students' cognitive processes to more aspects of engagement and how technology currently allows students to engage with learning (Redmond et al., 2018). Garrison's (2011) Community of Inquiry Framework for e-learning has three interrelated types of presence—social, cognitive, and teaching—enhancing students' educational experiences. When these three dimensions inform online course design, students and their educators share a community focused on collaborative learning and thinking (Garrison, 2018). Fredricks et al. (2004) define engagement as a multidimensional construct operating at behavioural, cognitive, and emotional levels for a deeper student relationship with mathematics. However, it has been challenging to measure online engagement, particularly in higher education.

There are a few frameworks that were used to measure student engagement. Bote-Lorenzo and Gomez-Sanchez (2017) identified 16 indicators to measure student engagement in an online course, including the percentage of totally watched lecture videos and assignments submitted. In mathematics education, Fredricks et al. (2004) measured engagement in relation to behavioural, cognitive, and emotional levels resulting in a deeper understanding of mathematics concepts. Redmond et al. (2018), which informed the current study, proposed the OEF for higher education comprising five dimensions (see Table 1). Redmond and colleagues identified several indicators representing each engagement dimension. The authors recommended the framework as an "audit tool or point of reference" (p. 196). This framework informs this study for two reasons: it describes each dimension, and the context of the framework is in higher education.

As shown in Table 1, PSTs create purposeful and trusting relationships with others in social engagement. Cognitive engagement involves "the active process of learning" (p. 191), and behavioural engagement involves "demonstrating positive learning behaviours and attitudes" (p. 193). A collaborative engagement included "the development of different relationships and networks that support learning, including collaboration with peers, instructors, industry, and the educational institution" (p. 194), and emotional engagement "related to feelings or attitudes towards learning" (p. 195).

Table 1
Online Learning Engagement Framework (Redmond et al., 2018, p. 190)

Engagement	Indicators (illustrative only)
Social	Building community, creating a sense of belonging, developing relationships, and establishing trust
Cognitive	Thinking critically, activating metacognition, integrating ideas, justifying decisions, developing deep discipline understandings, and distributing expertise
Behavioural	Developing academic skills, Identifying opportunities and challenges, developing multidisciplinary skills, developing agency, upholding online learning norms, supporting, and encouraging peers
Collaborative	Learning with peers, relating to faculty members, connecting to institutional opportunities, and developing professional networks
Emotional	Managing expectations, articulating assumptions, recognising motivations, and committing to learning

Methodology

This study is part of a larger study conducted at a School of Education and a Pathway College at a regional university in Australia across four courses. The School of Education prepares early childhood, primary and secondary school teachers. The Pathway College provides alternative entry options to enter university. This study focused on a primary program mathematics education course. The course has been designed to provide PSTs with various pedagogical and content knowledge understandings to teach mathematics in the primary school context. Zoom was used to share Padlet and GD in breakout rooms and share screens. Padlet activities were mostly reflections upon lectures and gathering PSTs' feedback and ideas anonymously about tutorial topics. GD was used to create problem solving activities using Google Sheets. The GD and Padlet were also made available asynchronously to involve PSTs who did not attend the live sessions. The live sessions were attended by 8 to 20 PSTs. Panopto quizzes were used in five lecture videos. One quiz in each video was located either at the beginning, middle or end of the lecture videos. The quizzes consisted of three or more questions formatted as multiple-choice or fill in the blank as part of the lecture viewing experience.

Data Sources and Participants

The data were collected from PSTs enrolled in the primary program mathematics education course. The data were collected using a survey, observation and web analytics. The survey comprised of a series of PSTs' experiences using Padlet, GD and video embedded quizzes. The survey was administered online through Google forms with 5-point Likert scale questions ranging from "5 = Strongly Agree" to "1 = Strongly Disagree." The questions were adapted from Redmond et al. (2018) OEF indicators except for the emotional dimension. For example, the question, "Padlet helped me think critically" was included to understand PSTs' level of agreement on their cognitive engagement while using Padlet (see Table 1). The authors believe that the emotional dimension is difficult to capture using a survey and focused on the observation data to capture this dimension. Furthermore, demographic information, including gender, age, and mode of study, was collected. The survey was distributed to 90 PSTs; however, this study reports on the preliminary data from 12 PSTs responded to the survey. All the survey participants were female (n =12), and most of the participants were studying off-campus (n = 7) and full-time (n = 8).

All live online video sessions were recorded while PSTs were using GD and Padlet. The course lecturer conducted the observations as part of normal teaching duties; however, an observation checklist was used to evaluate PSTs' engagement. The checklist was adapted from our survey questions (yes or no), followed by descriptive examples. A total of four video recordings with durations of 10 to 30 minutes while using these technologies were analysed. Each of the two recordings integrated either Padlet or GD. The technology, the PSTs who attended the live session (*n*), description of the topics, and activities are described in Table 2. Some of the live session participants could be different from survey participants.

Table 2
Technologies, Number of PSTs Involved in the Live Session (n) and Topics Taught

Video	Technology	PSTs(*n*)	Topic	Activity description
1	Padlet	20	Numeration system	Reflect on various numeration system and their experiences at schools
2	Padlet	12	Teachers' knowledge for teaching mathematics with technology	Reflect and comment on various forms of teachers' knowledge for teaching mathematics
3	GD	15	Learning mathematics with technology	Identify sum, mean, and generate graphs to identify the best technology for teaching a specific mathematics concept
4	GD	8	Problem based learning for effective mathematics teaching	Solve problems through posting pictures, generating graphs and calculations from the provided data

Panopto videos were used to embed the quizzes in the course lecture video and were available to all PSTs (n = 90). Panopto is a media tool with interactive features such as embedded quizzes and learning analytics. It allows one to see who has taken the quiz and their results and quiz scores. The PSTs who participated in the embedded quizzes and Padlet were identified from the Panopto and Padlet analytics.

Analysis

The data collected using the survey were summarised using descriptive statistics, including numerical data showing the strength of participants' responses to the survey items. The observation checklist rated PSTs' engagement by watching video-recorded lessons and making notes in the space provided in the observation checklist emphasising those parts of the lessons relevant to the research question. Consistent with the advice of Barron and Engle (2007), the analysis emphasised aspects of how the PSTs use the technologies to enhance their engagement. A deductive quantitative count was conducted during the analysis to describe the PSTs' engagement and calculate the frequencies of the occurrences of each engagement dimension.

Results and Discussion

Survey and Analytic Data

The PSTs' perception of the use of technology for teaching is presented in Table 3. Table 3 shows that PSTs tended to agree, for example, with being confident to use technology in learning (M = 4.25) and strongly agreed that learning with technology will influence how they teach with technology in the future (*M* = 4.58). However, they were not sure about the importance of learning with technology (*M* = 3.00).

Table 3
Pre-service Teacher Perception of Technology Use in Teaching

Items	Mean (*n* = 12)
I am confident using technology for learning at the University	4.25
I am confident teaching with technology	3.75
Learning with technology is important to me	3.00
Learning with technology will influence how I teach with technology in the future	4.58
The university courses offer good opportunities for learning with relevant technologies	4.00

Strongly agree = 5, Agree = 4 Neutral = 3, Disagree = 2, Strongly disagree = 1

PSTs have shown various levels of agreement on using the technologies to facilitate the various domains of engagement in studying the mathematics education course (see Table 4).

Table 4
Pre-service Teachers Mean Agreement on Technologies Engagement (n = 12)

Elements	Indicators	GD	Padlet	Panopto quiz
Cognitive	Think critically	3.25	3.50	3.50
	Develop deep discipline understandings	3.25	3.50	3.58
	Use expertise gained from other courses	3.25	3.50	3.42
Behavorial	Develop academic skills	3.00	3.50	3.67
	Develop agency	3.50	3.50	3.50
	Understand online learning norms	3.42	3.67	3.50
Collaborative	Engage with lecturers or tutors	3.50	3.67	3.33
	Connect to opportunities at the university	3.33	3.33	3.33
	Develop professional networks	3.00	3.25	3.25
Social	Create sense of belonging	3.25	3.25	3.25
	Develop relationship with others	3.33	3.50	3.25
	Develop a sense of community among others	3.33	3.42	3.33

Strongly agree = 5, Agree = 4 Neutral = 3, Disagree = 2, Strongly disagree = 1

The PSTs were unsure that GD enhanced their cognitive engagement (e.g., thinking critically). However, they agreed on the importance of Padlet and Panopto quizzes increasing their cognitive engagement, such as developing deep mathematics content understandings which echoed Salvatierra Melgar et al.'s (2021) suggestions of using technologies to enhance PSTs' mathematical knowledge. The PSTs agreed that Padlet and Panopto quizzes facilitated their behavioural engagement more than GD. However, PSTs equally valued the importance of GD, Padlet and Panopto quizzes to enhance their collaborative engagement. Similar to the findings of Ellis (2015), Padlet (e.g., developing a relationship with others) and GD (e.g., developing a sense of community) facilitated PSTs' social engagement.

The results presented in the following section are derived from the Panopto and Padlet analytics. Table 5 reports PSTs' engagement report from the Panopto quizzes. There was a noticeable difference between the number of PSTs accessing quizzes in relation to their placement within the video. The low percentage of PSTs accessing quizzes was shown either in the middle or end (12.2–22.2%). The PSTs tended to attempt the quizzes when they were located at either the beginning or middle of a video. The PSTs were less likely to attempt the quizzes when located at the end of a video.

Table 5
Primary Course Panopto Quizzes Engagement Pattern (n = 90)

Video	Location of quiz in video	Type of quiz	# of questions	Video length	# PSTs accessed
1	Beginning	Mixed	4	4:00	38 (42.22%)
2	Middle	Multiple	3	3:00	20 (22.22%)
3	Middle	Multiple	5	3:00	19 (21.11%)
4	End	Multiple	7	3:00	9 (10.00%)
5	End	Mixed	6	2:00	11 (12.22%)

Padlet provides limited information on its analytics system; however, the number of posts, comments and contributors were accessible. There were 123 posts and 20 comments from 50 PSTs contributors, which might indicate high involvement of the PSTs.

Observation Data

The recorded sessions, which integrated with Padlet and GD, were analysed, and the results are reported in Table 6.

Table 6
Pre-service Teachers Engagement in Padlet and GD on Observed Frequencies

Elements	Indicators	GD (*n*)	Padlet (*n*)	Descriptive example
Cognitive	Think critically	11	5	*GD:* PSTs discussed critical ideas while interpreting the data provided. *Padlet:* To craft responses to questions
	Develop deep discipline understandings	13	6	*GD*: Raised and answered questions from data *Padlet*: Represent a number using a different number system
	Use expertise gained from other courses	7	3	*GD and Padlet*: Drew upon previous mathematics courses to answer questions
Behavorial	Develop academic skills	12	4	*GD*: Learned calculating mean, Standard Deviations etc. in Google Sheets
	Develop agency	4	5	*GD:* Supported each other while using formulas in Excel Padlet: Supported the other PSTs on how to embed video in Padlet
	Understand online learning norms	7	5	*GD and Padlet*: Tracked while reflecting after the live sessions
Collaborative	Engage with lecturers or tutors	10	8	*Padlet*: Answered questions for the lecturer in text form
	Connect to opportunities at the university	0	0	
	Develop professional networks	7	8	*GD and Padlet:* PSTs shared links

Social	Create sense of belonging	4	7	*GD and Padlet:* PSTs managed activities while working in groups
	Develop relationship with others	8	4	*GD*: worked in pairs to answer questions *Padlet:* Commented on other PSTs responses
	Develop sense of community	8	6	*GD and Padlet*: worked in groups and created a community for further discussion
	Managing expectations	2	3	*GD and Padlet*: Commented on the expectations to the activities
	Articulating assumptions	2	9	*GD and Padlet:* supported each other to explain assumptions
Emotional	Recognising motivations	1	5	*GD and Padlet:* PSTs appeared motivated to calculate on Google Sheets and comment in the Padlet
	Committing to learning	4	7	*GD and Padlet*: Carefully finished the activities on time

The observational data showed that both Padlet and GD engaged the PSTs across all five dimensions of Redmond et al.'s (2018) framework to different degrees. When PSTs were using Padlet there were instances of engagement across all dimensions but mainly on the emotional dimension (*n* = 23), such as PSTs articulating their assumptions about what they were learning (*n* = 9) and the motivation about why they were learning those topics (*n* = 5). GD better supported PSTs to engage cognitively (*n* = 31) and behaviourally (*n* = 23). Similar to the findings of other studies (e.g., Lee & Martin, 2020; Salvatierra Melgar et al., 2021), the cognitive engagement included developing deep discipline understandings (*n* = 13) and thinking critically (*n* = 11). Examples of social engagement promoted by GD included developing a sense of community among others (*n* = 8) and developing relationships with others (*n* = 8). However, the emotional dimension was least observed while using GD (*n* = 9).

Conclusion

The research question guiding this study was:

How do embedded technologies enhance PSTs' engagement in an online mathematics education course?

The study used Redmond et al's. (2018) OEF to analyse the data. The PSTs were engaged in various domains of engagement, particularly the dimensions beyond cognitive and behavioural, which are additional dimensions to the previous studies (e.g., Fredricks et al., 2004; Garrison, 2011). The technologies showed minimal support for PSTs' emotional engagement; however, they enhanced their cognitive, social, and collaborative engagement. As evidenced by the survey and observation results, the role of each technology on PSTs engagement is shown in Table 7.

Padlet was beneficial to PSTs who wished to contribute anonymously to the live sessions. The observation results further showed that GD, combined with Zoom breakout rooms, works well for focused group activities. The quizzes embedded within lectures supported seamless formative feedback and influenced PSTs' cognitive and behavioural engagement. There was a strong inference that Padlet technology encourages emotional engagement. Its flexible layout allows PSTs to participate via text, audio, and images.

Table 7

Padlet, GD and Video Quiz and Summary of their Contribution to Engagement

Element	Padlet		Video quiz		GD	
	Survey	Observation	Survey	Observation	Survey	Observation
Cognitive	Agree	31	Agree	N/A	Neutral	14
Behavioural	Agree	23	Agree	N/A	Neutral	14
Collaborative	Neutral	17	Neutral	N/A	Neutral	16
Social	Neutral	20	Neutral	N/A	Neutral	17
Emotional	N/A	9	N/A	N/A	N/A	24

N/A – observation or survey was not conducted; numbers indicate frequencies observed

The PSTs valued the importance of GD for cognitive engagement, including thinking critically, developing deep mathematics content understanding and developing academic skills. In addition, using GD provided strong support for social and collaborative engagement. However, the emotional dimension was the least observed while using GD due to the nature of the activities, which focused PSTs on collaborative problem-solving and discussion. The results showed that using the technologies in teaching can enhance PSTs engagement and improve their use of various technologies for their future profession. In addition, it showed the importance of teacher educators understanding and identifying the types of technologies most suitable to enhance each engagement dimension. The small sample and the few selected technologies, however, limit the generalisability of the study. In addition, the specific topic being taught might have influenced the applicability of the findings. Future research could benefit from more robust samples and studying specific mathematics contents.

References

Attard, C. (2018). Mobile technologies in the primary mathematics classroom: Engaging or not? In D. Martinovic & V. Freiman (Eds.), *Mathematics education in the digital era* (pp. 51-65). Springer.

Attard, C., & Holmes, K. (2020). "It gives you that sense of hope": An exploration of technology use to mediate student engagement with mathematics. *Heliyon*, *6*(1), 1-11. https://doi.org/10.1016/j.heliyon.2019.e02945

Barron, B., & Engle, R. A. (2007). Analysing data derived from video records. In S. J. Derry (Ed.), *Guidelines for video research in education: Recommendations from an expert panel* (pp. 24–43). Data Research Centre.

Bote-Lorenzo, M. L., & Gómez-Sánchez, E. (2017). Predicting the decrease of engagement indicators in a MOOC. In *Proceedings of the Seventh International Learning Analytics & Knowledge Conference* (pp. 143–147). https://doi.org/10.1145/3027385.3027387

Dianati, S., Nguyen, M., Dao, P., Iwashita, N., & Vasquez, C. (2020). Student perceptions of technological tools for flipped instruction: The case of Padlet, Kahoot! and Cirrus. *Journal of University Teaching and Learning Practice, 17*(5), 1–14. https://doi.org/10.53761/1.17.5.4

Ellis, D. (2015). Using Padlet to increase student engagement in lectures. *Proceedings of the European Conference on E-Learning,* pp. 195–198. http://www.academic-conferences.org/conferences/ecel/

Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, *74*(1), 59–109. https://doi.org/10.3102/00346543074001059

Garrison, D. R. (2011). *E-learning in the 21st century: A framework for research and practice*. Routledge.

Lee, Y., & Martin, K. (2020). The flipped classroom in ESL teacher education: An example from CALL. *Education and Information Technologies*, *25*(4), 2605–2633. https://doi.org/10.1007/s10639-019-10082-6

Prince, T. (2016). "Panopto" for lecture capture: A first time user's perspective. *International Journal of Innovation and Research in Educational Sciences, 3*(5), 261–266. https://www.learntechlib.org/p/172055

Redmond, P., Heffernan, A., Abawi, L., Brown, A., & Henderson, R. (2018). An online engagement framework for higher education. *Online Learning, 22*(1), 183–204. http://dx.doi.org/10.24059/olj.v22i1.1175

Salvatierra Melgar, Á., Neptalí Cavero-Aybar, H., Quisocala Herrera, J. A., & Carlos Augusto, L. M. (2021). Mentimeter and data on college student engagement in mathematics learning. *International Journal of Nonlinear Analysis and Applications*. https://ijnaa.semnan.ac.ir/article_5696.html

Suwantarathip, O., & Wichadee, S. (2014). The effects of collaborative writing activity using Google Docs on students' writing abilities. *Turkish Online Journal of Educational Technology, 13*(2), 148–156.