Using an Online Engagement Framework to Redesign the Learning Environment for Higher Education Students: A Design Experiment Approach

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Abstract
With more higher education courses being offered online, the design of the learning environment is an essential component of the educational experience. However, not all online learning environments facilitate student engagement. This paper describes the redesign of two online Initial Teacher Education courses in a regional university, using the Online Engagement Framework (OEF) for higher education. Following a design experiment approach, the online components of the course were audited and redesigned with consideration to the five elements of online learning and engagement. To understand the effectiveness of the redesign, we analysed student feedback from 24 course offerings along with course analytics. Data indicated an increase in student engagement, as well as feedback indicating students highly valued the cognitive, behavioural, and emotional elements of their online courses. The paper reinforces the importance of forefronting student input in course redesign, and offers timely and practical considerations to guide course redesign.

Keywords: Online learning, regional university, student engagement, teacher education, student success.

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The online learning environment plays an essential role in higher education, influencing how students perceive and engage with content in their courses (Krishnan, 2016). However, the effectiveness of the educational experience in online learning in higher education contexts varies greatly (Deng & Tavares, 2015). While online learning already existed in higher education programs and contexts, COVID-19 provided an impetus for a rapid transition to digital Learning Management Systems (LMS) for many universities globally (Marfuah et al., 2022). As more courses are offered through online offerings, online student engagement, understood to include behaviours that indicate regular synchronous, or asynchronous, participation in activities and commitment to learning (Brown et al., 2023; Redmond et al., 2023), has been forefronted (Bledsoe, 2013; Martin et al, 2018). Ensuring student engagement in the course design is important for the effectiveness of learning, as an essential component of the educational experience, and can be leveraged to support the completion of coursework, retention, and academic success (Costa et al., 2018).

In order to examine the types of engagement students experience in online learning environments, Redmond et al. (2018) developed an Online Engagement Framework (OEF) for higher education, built upon recurring themes within the literature, including students' beliefs, attitudes, and behaviours. The framework goes beyond a Community of Inquiry model (Garrison & Akyol, 2013), to identify other essential elements and considerations, such as emotional and collaborative engagement, which are asserted to be a crucial part of the online design process for higher education. With a desire to create a learning environment that supports student engagement in Initial Teacher Education (ITE) courses, this paper explains how the online learning environments of two ITE courses were audited and then intentionally redesigned using a design experiment methodology to support the five elements of student engagement from the OEF. It then presents an analysis of course survey reports to show how the new courses designs impacted students' online engagement and their overall satisfaction with the learning experience. Finally, major themes and recommendations for higher educators and course designers are discussed. This paper provides a significant contribution, by outlining a process to audit an online learning environment, as well as offering timely, and practical strategies, underpinned by theoretical reasonings to inform decision-making for course redesign of ITE courses and, more broadly, for programs within the higher education sector.

Background Literature

One of the challenges faced by designers of ITE programs is the increasing cohort of students who choose to study entirely online (Tualaulelei et al., 2022). Statistically, mature-aged students who study online and part-time are at more risk of disengagement from tertiary study due to a range of external difficulties (Costa et al., 2018), such as working full-time and supporting families (Stone & O'Shea, 2019). The complexity of factors underpinning this demographic heightens disengagement, with risk factors that include the diversity of the cohort (Dart & Spratt, 2021), student anxiety (Roland et al., 2018) and feelings of disconnectedness (Stone & O'Shea, 2019), all of which may affect students' ability to engage online.

In considering how to design online courses to support student learning and success, Stone et al. (2019) found that providing content in different modes (such as videos, eBooks, forums and tutorials) provided flexible learning options to better suit students' diverse needs and

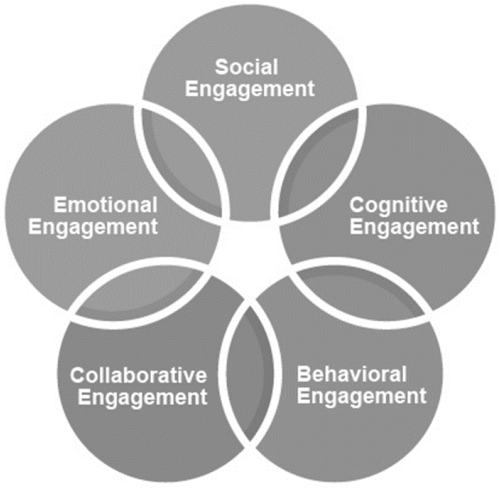
learning styles. In a study of over 600 students, including those studying mathematics, Burke & Fanshawe (2024) found that time pressure was an essential consideration for learners. Students being time-poor had implications for course design, particularly in terms of providing students with ways that enabled easy access to engage in the course, along with learning materials that afforded flexible study options and ways of working (e.g., opening all components of the course upfront; considerations about the timetabling of tutorials). Communicating expectations with students was found to increase student engagement and help reduce stress levels for ITE students (Burke & Fanshawe, 2024). Therefore, in an online learning environment, innovative design and supports are necessary to facilitate students' engagement in their learning.

A Conceptual Framework to Support Student Engagement

Working in ITE, Redmond et al. (2018) produced an engagement framework that provides a guide for online learning environments in higher education. The framework identified five crucial elements for engaging students in learning in online teaching spaces: behavioural, cognitive, social, collaborative, and emotional engagement, as shown in Figure 1. As the descriptions of the elements indicate, Redmond et al. (2018) adopted a broad view of engagement, drawing on extensive research from the field to develop the framework.

Figure 1

Image Adapted from the Five Elements of the Online Engagement Framework (Redmond et al, 2018)



Cognitive engagement is the active learning process related to what students do and think to promote learning. Indicators of cognitive engagement include thinking critically, activating metacognition, integrating ideas, and developing deep discipline understandings (Redmond et al, 2018). Online learning tasks that engage students on a cognitive level ask them to think critically about issues, integrate new ideas, develop and justify their position or understanding, or engage in metacognition (Redmond et al., 2018).

Behavioural engagement relates to participation and involvement in learning activities and academic pursuits that contribute to successful learning outcomes. Indicators of students' behavioural engagement include participation in, and completion of, learning activities, learning involvement through effort and persistence, supporting and encouraging peers and the development of student agency through activities that are meaningful and relevant (Wang, 2017). It has been recognised that course design that entices students' behavioural engagement early in the semester may be a precursor in developing and promoting deeper engagement and related student achievement (Wang, 2017).

Collaborative engagement is related to students' engagement with others and therefore is similar to social engagement. However, the focus is on academically worthwhile purposes such as collaborative discussion forums, tutoring, study groups, and group tasks or assessment. Redmond et al. (2018) suggest that students studying online are more likely to collaborate online because they are less likely to be located geographically near peers. Collaborative engagement also relates to students connecting to the university and the development of relevant industry professional networks.

Emotional engagement is about students' feelings or attitudes towards learning and is engagement's affective or emotional component. For example, in a mathematics-based ITE course, emotional engagement is particularly pertinent due to ITE students' often negative perceptions of mathematics and mathematical abilities (Everingham et al., 2017). Indicators that exemplify emotional engagement include managing expectations, articulating assumptions, recognising motivations, and committing to learning.

Finally, *social engagement* refers to students' social investment in the tertiary experience. It supports learning through building community, creating a sense of belonging, and helping students create purposeful relationships with others (Chen et al., 2010). It refers to informal opportunities for students to build rapport and trust in the online space and more formal connections that support learning.

Therefore, in pursuit of creating an online learning environment which would facilitate student engagement in their learning, we posed this research question*:*

> Can the Online Engagement Framework be used to as a tool to re-design a course to increase student engagement?

Methods

The researchers involved in this project were higher education academics from the School of Education in a regional Australian university, where the student cohort was predominately online (>75%) pre-COVID-19. We were all interested in creating engagement in online learning environments to ensure students were able to access content and prepare for future employment.

Our study was conducted over a seven-year period, from 2017 to 2023. The goal was to redesign two mandatory ITE courses, a first-year course (Y1), and a third-year course (Y3), both

of which had an overarching goal of providing curriculum and pedagogy preparation for mathematics teaching in primary schools. The first author was the course writer and examiner for both courses, and the second and third authors, more senior academics, provided mentoring support with redesign considerations. At the time, the OEF had just been published by the 2nd and 3rd authors, and so afforded a tool for auditing and reflecting on possible strategies to facilitate student engagement in the online course redesign.

Research Design

The redesign of the courses followed the three steps of the methodology for design experiments in education, as proposed by Cobb et al. (2003). The use of design-based research in education has been identified as important because it has the potential to influence the teacher's professional practice (Fowler et al., 2022). Design experiments are conducted to develop theories, but are also pragmatic, as they study the resulting learning within the context of the design. Cobb et al. (2003) suggested three steps to redesign learning experiences, which are outlined below.

Step 1: Preparing for a Design Experiment

In order to prepare for a design experiment, Cobb et al. (2003) suggested a review or audit of the existing course be undertaken, complemented by an understanding of the students and researchers and the outcomes the re-design hopes to bring.

A review of the inherited courses found that the course content consisted of:

- recorded lectures and additional resources, typically in PDF files uploaded in each week's content (cognitive element);
- an assessment section with information regarding the assignments and criteria (cognitive element);
- discussion forums intended for peers to discuss topics (social element) and not monitored by teaching staff; and
- a study schedule with expected readings and content to complete (behavioural element).

An audit of existing data, including learning analytics and course survey reports, showed low participation and satisfaction with the course. Course learning analytics includes data generated by the LMS which can be used to identify the number of students who have interacted with each element of the course content (Tualaulelei, et al., 2022). While course analytics cannot tell if a student has made a cognitive connection with the materials, the data did provide an understanding of what materials were being "accessed" by the students, and who was interacting in the discussion forums provided in the course. Hence, this was a good indicator of participation and engagement. Learning analytics, which were automatically generated through the LMS from Y3-S1-2017, showed students were accessing only 30.7% of course content. While 56.2% students accessed lecture resources, only 5.7% interacted (i.e. contributed or responded to a post) in the discussion forums.

Course survey reports are created for each course throughout the university at the completion of each semester. Students are invited to indicate their course satisfaction using a combination of rating scales (quantitative feedback), and open-ended question (qualitative feedback). The quantitative section of the surveys used a 5 point Likert-type scale, where 1 indicated "strongly disagree," and 5 indicated "strongly agree." Survey participants are also asked to respond to the statement "overall I am satisfied with this course." The qualitative responses to the open-ended questions provided anonymous feedback, which was not an indicator of engagement per se. Nevertheless, it was a means through which the students could provide a candid narrative on how they interacted with a course and its activities, the effects that instruction had on them, and how they perceived course learning activities (Linse, 2017). The course survey report for Y3-S1-2017 collected quantitative and qualitative data on student experiences following each course offering and indicated a score of 3.89 (maximum = 5) for student course satisfaction, with only 21.43% of the enrolled students providing feedback. These figures were regarded as low, because the university aimed for all courses to receive a score between 4.0 and 5.0, with a 25% response rate from students.

In addition, there had been a high rate of student attrition from the course. From 2015 to 2017, an average of 16% of students withdrew from the course. As one student explained, *I was very anxious about this course and dropped it three times before semesters began* (Y3-S1-2017). Similar findings were identified for the Y1 course, indicating the students were not engaging well in online mathematics courses.

Step 2: Conducting a Design Experiment

The second stage of the design experiment process was to seek to improve the initial design (Cobb et al., 2003). The redesign was conducted in 2017 through strategic implementation in the course design for each of the five of elements of engagement, as shown in Table 1 and summarised below.

Table 1

Comparative Elements of Course Design Pre- and Post-Redesign.

Type of engagement	Inherited courses	Course redesign and justification
Behavioural	• Study schedule with expected readings and content to complete	• Getting started section – included a video outlining the explicit intentions of the course • Weekly course updates emailed to students, or internal course NEWS announcements, to explain weekly content • Study schedule with expected readings and content to complete • Course layout – like an iPhone with all the information for one topic in one place. • Step-by-step instructions for assessment expectations
Cognitive	• Lectures – I hour pre-recorded • Tutorial – 2 hours pre-recorded	• Lectures – Moodle eBook – students can go through the content independently. Mini lectures recorded within the book – maximum of 10 mins

	• Course readings – uploaded in PDF • Assessment – 2 essays (90%), participation (10%)	• Tutorial – live via zoom and recorded – allow students to interact with lecturer and others (social and collaborative). Hands-on activities for praxis-based understanding of mathematical content • Course readings – linked directly to the university library for digital access • Assessment – praxis-based so students could engage with mathematics activities to keep as future resources in their classrooms.
Social	• Discussion forums "if students had questions"	• Introduction forum to meet other students • Check-ins – as well as tutorials, check-ins were an informal place just to come and talk about maths content the students may be doing in practicum placements one hour a week.
Collaborative		• Tutorials on Zoom with breakout rooms, so students could solve a maths problem collaboratively. • Meet-up leader – a students who had previously done the course to meet in an informal manner on Zoom with the students.
Emotional		• Personal emails to students to check-in on wellbeing and congratulate them for success in assignments. • Badges to reward and congratulate students for completing tasks. 

Cognitive elements added to the course included replacing the 2-hour lecture with a Moodle eBook which students could complete independently at a time that suited their schedule. Mini lectures (up to 10 minutes) were included in the eBook. Hands-on activities were included in the course re-design, providing practical learning activities that were aligned with the assessment tasks (Ayalon & Wilkie, 2020). In addition, individualised feedback for students was provided before the assessment, and in tutorials and forums, so the students would have the opportunity to address misconceptions before submitting assessment, as well as a positive opportunity to reaffirm their efforts and thinking (emotional engagement).

To provoke and challenge students and thus engage them cognitively, online learning activities were designed to present the content that helped students develop an understanding of the discipline (Kennedy, 2020). Real-world examples and hands-on investigations involving active participation were included, with students using materials around the home to facilitate learning (Simon, 2022).

Behavioural elements were included in the redesign to entice students to engage in the courses by replicating the design of an iPhone, with content accessed by clicking on an icon that mimicked the image of an "app" on the iPhone (see Figure 2). The intention was to create a design that would be more intuitive for students, particularly supporting students who were less confident with technology to access the the Moodle learning management system (Kilgour et al., 2019).

Figure 2

The Online Interface Design That Mimicked iPhone Format

To additionally guide behavioural engagement, a *Getting Started* section was added, which included a video that explicitly outlined the intentions of the course and step-by-step assessment instructions to outline assignment expectations in the course. Weekly announcements, which were also sent as emails to the students, were created to guide students' study direction for each week. A number of Activity Tracking tools, already embedded in the LMS, were harnessed to provide nudges to students to engage in required activities (Lawrence et al., 2021).

To encourage collaborative and social engagement in online interactions, the redesign recognised that, by nature, people are social beings, and today's innovations such as virtual classrooms in the LMS provide virtual spaces that enable teacher presence and student interactions. These considerations were critical in designing the learning environment and fostering an online learning community.

Collaborative elements were included in online tutorial sessions. Rather than a pre-recorded tutorial, synchronous tutorials were available which also allowed students an opportunity to interact with the lecturer and other students. Breakout rooms were used so students could solve a problem collaboratively, at the same time deepening their understandings of content. It was also acknowledged that not all students could attend tutorials, so forums were set up as an alternative for students to share responses to activities and their reflections. These intentional engagement strategies reflecting the theory that affirms that learning together can nurture a positive mindset and learning from and with others helps students, whilst also recognising and manage anxiety in educational settings (Russell & Topham, 2012).

Another major component of the course redesigns was the integration of emotional elements. These efforts strategically considered that emotional engagement impacts student motivation to learn, which has a flow-on effect on student satisfaction (Kucuk et al, 2019). Teacher presence was created by including an avatar, a digital representation of the teacher (Falloon, 2010), integrated and used throughout the course materials. As well, the instructor created digital badges to send instantaneous feedback to students (Fanshawe et al., 2020), thus fostering a positive sense of achievement as students progressed through the course (Dowling-Hetherington & Glowatz, 2017). Badges were intended to offer a personalised feeling to the course, so students felt supported but also helped add behavioural guidance to the course, so students completed activities to receive a badge. Personal emails were sent to each student prior to assessment to check on their progress and remind them of supports available (Dart & Spratt, 2021). As an additional support, a student who had previously completed the course was employed as a peer leader to meet students in an informal manner on Zoom and assist current students with any course or university questions (Kimmins, 2013).

Social elements of the redesign included an introduction forum/social forum that invited students to introduce themselves, share a little bit of their background and goals for the course and build initial connections and trust with the fellow students. As well as tutorials, check-ins were added, which were an informal place to discuss mathematics content that the students may be doing in practicum placements for one hour a week. The check-ins provided an opportunity for students to engage informally with each other in the course.

Step 3: Conducting Retrospective Analysis

The final step of the design experiment process was to evaluate the effectiveness of the redesign, to answer the research question "How can the Online Engagement Framework be used to as a tool to re-design a course to increase student engagement?" Prior to commencing this stage, ethical approval was gained from the University Human Research Committee to use current and retrospective data to evaluate the courses (approval # ETH2020-0100, ETH2023-0847).

Data Collection

Data were collected from two mathematics courses scheduled in the first and third year which were mandatory in the ITE program. Data were collected between 2018 and 2023, over 13 iterations of the Y1 course and 11 iterations of the Y3 course, following the redesign of the two courses at the end of 2017. Data collected included the course survey report (quantitative and qualitative) and course learning analytics (quantitative).

Data Analysis

Quantitative data from the course survey report and course analytics of participation of online students were collated from each offering and compared using simple comparative analysis. To analyse the qualitative data from the course survey report we used thematic content analysis. This approach examines the data and looks for the meaning of the words prior to coding (Maguire & Delahunt, 2017). First, the data references for each course offering (n=24) were examined for how they aligned with any of the five elements of the OEF. This involved the researchers drawing meaning from the text and highlighting parts of the student comments in the course survey report that related to each element of engagement. The coding was performed separately by two authors, who then met with the remaining author to discuss any differences in the results. This helped to ensure research rigour and increase data dependability.

Next, the qualitative data for the two courses (24 offerings) were combined for analysis. To further ensure validity, the comments were uploaded into NViVO, a tool which enabled us to identify key words used throughout the students' data. The data sets related to each engagement element were manually analysed to identify themes that represented specific engagement elements that students perceived as having supported their learning in the online environment.

Findings and Discussion

This section of the paper addresses the analysis of the quantitative data obtained from the course survey reports, along with themes from the qualitative data presented in the findings for each data set. Data from the learning analytics is presented initially, and then again in relation to the qualitative data descriptions, to enable a comparison of student comments and activity on the LMS.

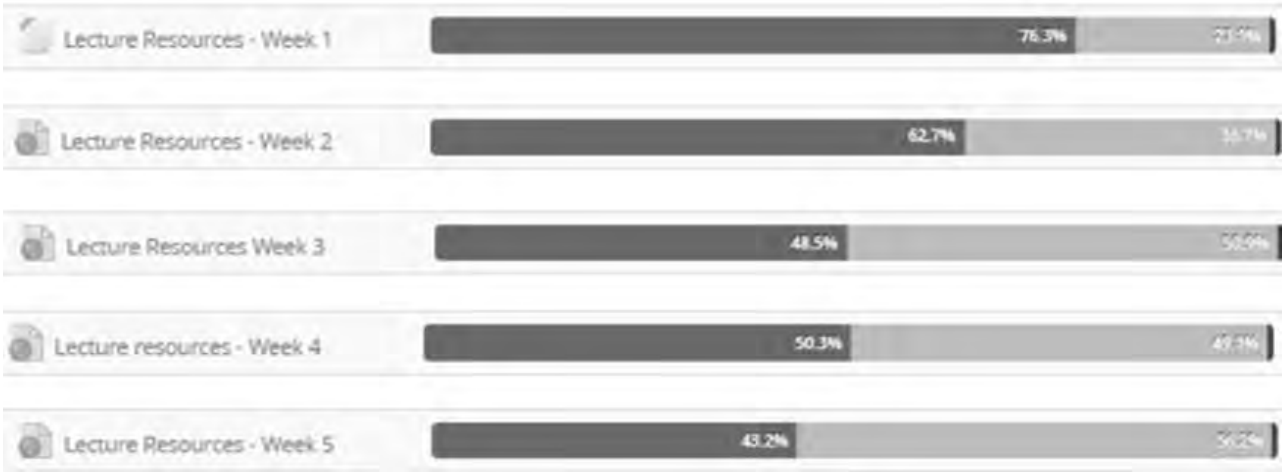
Learning Analytics

A significant finding was the impact of the course redesign on students' engagement with the cognitive aspects of course content. For example, Figure 3 shows a comparison of learning analytics of the lecture resources in the third-year course, Y3-S1-2017, where green represented the percentage of students who accessed the lecture resource, yellow represented the percentage of students who did not access the resource, and black indicated the percentage of students who had not yet accessed the course. Prior to the redesign, the average access to the first five lectures was 56.2% of students. However post-redesign, 91.46% of students in Y3-S1-2018 evidenced access to the Moodle books, indicating an increase in engagement in cognitive learning content post redesign for these courses.

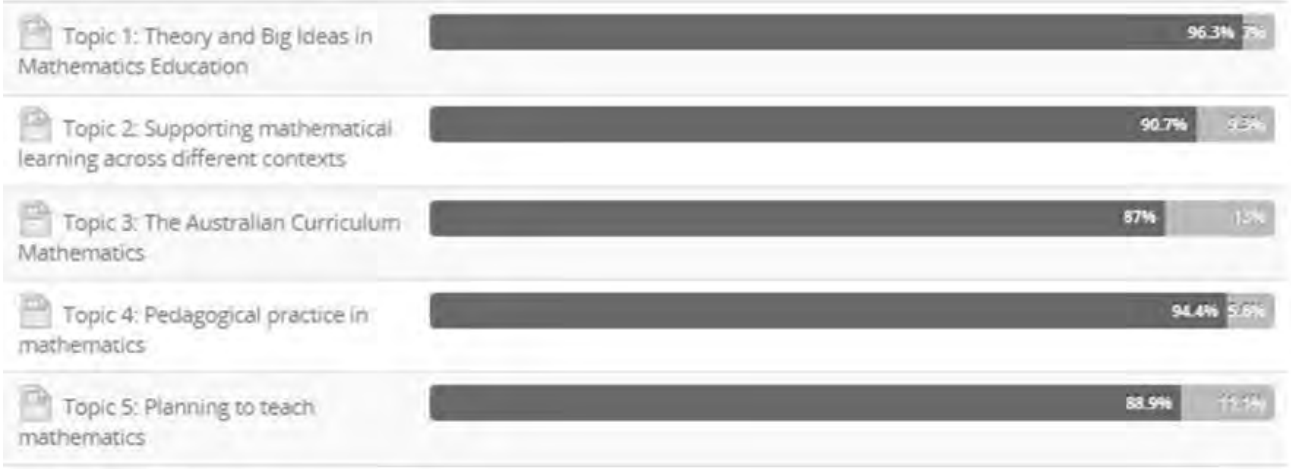
Figure 3

Comparative Learning Analytics Y3-S1-2017 & Y3-S1-2018 Immediately Pre and Post redesign.

Pre-change



Post-change



Learning analytics data highlighted that increased access to the course has been consistent since the redesign. Data from 2020 to 2023 showed students accessed an average of 76% of the course content (Table 2). Participation in course elements was slightly higher for students enrolled in the first-year subject at 78.14%, as opposed to 74.75% for the third-year subject.

Table 2

Learning Analytics Data Showing Average Percentage of Course Content Accessed by Students from 2020 to 2023 for Y1 and Y3 Courses.

Y1 course	**S1 2020**	**S2 2020**	**S1 2021**	**S2 2021**	**S2 2022**	**S3 2022**	**S2 2023**	**Total**
# Students	46	144	158	124	116	80	168	836
Average %	80.12%	79.94%	79.27%	73.85%	85.95%	86.67%	80.66%	78.14%
Y3 course	**S1 2020**	**S1 2021**	**S3 2021**	**S1 2022**	**S3 2022**	**S1 2023**		**Total**
# Students	53	86	74	83	102	90		488
Average %	70.66%	73.88%	79.91%	72.64%	75.32%	75.22%		74.75%

Course Survey Report: Quantitative Data

The quantitative data from the course survey report comprised Likert scale responses from 570 students; 332 and 238 in Y1 and Y3, respectively. These figures represented 31% and 28% of students enrolled. Table 3 shows the details of student evaluation scores, and response rates for each of the course offerings. The redesigned Y1 received an average of 4.66 for overall student satisfaction with a 31% response rate. The Y3 received an average of 4.56 for overall satisfaction with a 28% response rate. The large majority of 570 students responded with a 4 (satisfied), or a 5 (very satisfied) on the Likert scale, indicating that most students agreed or strongly agreed that it was a good course.

Table 3

Evaluation Scores, Numbers of Students Who Responded, Response Rates and Qualitative Data References for Each of the Examined Course Iterations

First year course				**Third year course**			
Offering	Score/5	#Students	Response rate	Offering	Score/5	#Students	Response Rate
S2 2023	4.5	32	19%	S1 2023	4.5	18	20%
S3 2022	4.9	24	30%	S3 2022	4.7	20	20%
S2 2022	4.9	26	22%	S1 2022	4.5	15	18%
S2 2021	4.5	30	24%	S3 2021	4.5	8	11%
S1 2021	4.2	39	25%	S1 2021	4.5	18	21%
S2 2020	4.7	40	28%	S1 2020	4.8	16	30%
S1 2020	4.6	13	28%	S2 2019	4.5	20	36%
S2 2019	4.6	28	35%	S1 2019	4.4	15	49%
S1 2019	4.5	34	44%	S3 2018	4.5	63	36%
S3 2018	4.6	19	40%	S2 2018	4.5	17	21%
S2 2018	4.9	17	41%	S1 2018	4.8	28	45%
S1 2018	4.8	30	45%				
Total	4.66	**332**	31%	**Total**	4.56	**238**	28%

Data indicated that the student satisfaction score in all iterations of the two courses (range 4.2 to 4.9) surpassed the scores for 2017 (3.89 and 4.15). In other words, the students in 2018–2023 expressed more satisfaction with the mathematics courses than students had before the redesign. In addition, as shown in Table 4, student dropout from the courses was lower following the redesign of the courses. It should be noted that the university had an overall higher attrition in 2020–2022 which may be attributed to COVID-19. Regardless, the redesigned courses still remained below pre-course redesign attrition figures.

Table 4

Student Dropout Percentage Pre (2015–2017) and Post (2018–2023) Course Design.

Pre-course redesign			**Post-course redesign**					
2015	2016	2017	2018	2019	2020	2021	2022	2023
16%	15%	17%	7%	4%	9%[1]	14%[1]	11%[1]	4%

[1] COVID-19 may have impacted attrition in 2020 -2022

The quantitative data from the course survey report shows decreased attrition rates for the redesigned courses. The findings show approximately 30% of students in 23 offerings of mathematics courses were satisfied or very satisfied with the course following the redesign. The analysis of the course report surveys found an improvement in student satisfaction from below university expectations of 4.0/5.0 to an average of 4.6 for the 24 offerings. These results indicate that the majority of students who responded were satisfied with the course.

Course Survey Report: Qualitative Data

To fully understand what elements of the course redesign were important to the students in their learning, we analysed the qualitative data from the course survey reports. In total 451 data references were collected from 23 offerings; which included 255 Y1 and 196 Y3 data references.

The first step of the coding of the qualitative data resulted in the allocation of the student comments into the five engagement elements identified in the OEF for each course. The data references were coded as 123 cognitive, 106 behavioural, 50 collaborative, 143 emotional and 30 social engagement, as shown in Table 5.

Table 5

Total Number of Data References Coded into Each Element of Engagement for Y1 and Y3 Courses.

First year	**Cognitive**	**Behavioural**	**Collaborative**	**Emotional**	**Social**	**Total**
Y1 S2 2023	6	4	3	9	1	23
Y1 S3 2022	5	4	3	6	1	19

Y1 S2 2022	7	4	1	5	3	20
Y1 S2 2021	6	2	5	5	3	21
Y1 S1 2021	3	2	3	8	4	20
Y1 S2 2020	5	6	1	9	1	22
Y1 S1 2020	3	1	0	6	0	10
Y1 S2 2019	3	7	2	6	2	20
Y1 S1 2019	4	5	2	6	1	18
Y1 S3 2018	3	8	1	6	1	19
Y1 S2 2018	8	12	3	14	2	39
Y1 S1 2018	6	5	4	7	2	24
Total Y1	61	60	28	86	21	255
Percentage	24%	23%	11%	34%	8%	

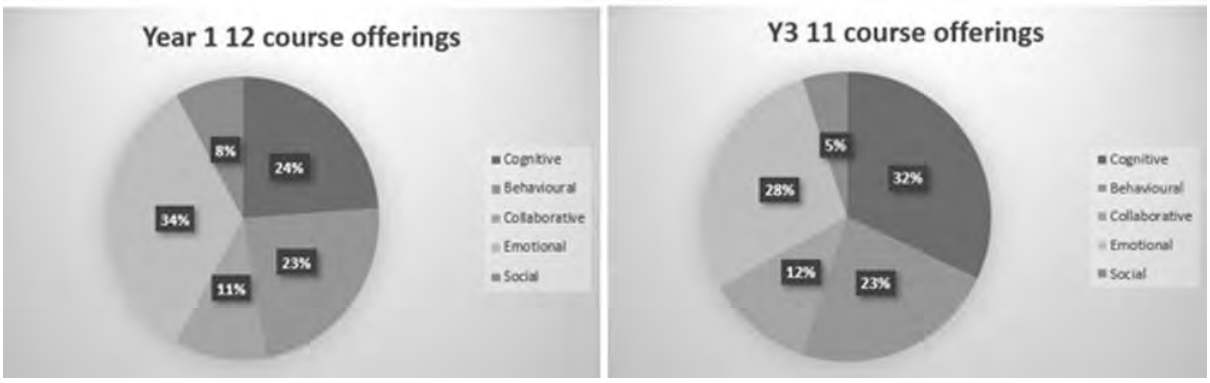
Third year	**Cognitive**	**Behavioural**	**Collaborative**	**Emotional**	**Social**	**Total**
Y3 S1 2023	4	5	1	4	1	15
Y3 S3 2022	4	6	2	4	1	17
Y3 S1 2022	9	3	2	1	3	9
Y3 S3 2021	2	2	1	1	0	6
Y3 S1 2021	4	2	1	3	1	11
Y3 S1 2020	2	2	0	1	4	9
Y3 S2 2019	2	1	0	2	1	6
Y3 S1 2019	16	9	1	9	0	35
Y3 S3 2018	12	6	9	17	0	44
Y3 S2 2018	1	2	1	1	0	5

Y3 S1 2018	12	9	5	12	1	39
Total Y3	62	46	22	57	9	196
Percentage	32%	23%	12%	28%	5%	

Interestingly, the distribution across the engagement elements was very similar between the two course offerings as shown in Figure 4. The only notable difference differences between Y1 and Y3 were cognitive and emotional engagement. In Y3 emotional engagement was higher (32%) than Y1 (24%). Emotional engagement was higher in Y1 (34%) than Y3 (28%).

Figure 4

Data References per Engagement Element, Represented as a Percentage of the Total Data References, by Course.



In the second step of the qualitative data analysis, the data sets related to the five engagement elements were manually analysed to identify themes that represented specific aspects of the elements that students perceived as having supported their learning in the online environment. The following sections present each of the elements of online engagement with students' comments (including year and course offering).

Cognitive Engagement

Cognitive engagement was coded for 123 references from the 23 courses. Evidence of cognitive engagement included comments about how students interacted with online learning tasks. Data from the course survey report indicated students particularly enjoyed the cognitive content of the course. The change from a lecture to a Moodle book was identified by students as a positive aspect of the redesign.

> I really dislike listening to lectures and find them a struggle to sit through. … Having the modules enabled me to engage the class resources (Y3-S1-2018).

> The information in the ebooks was easy to read (peppered with humour, anecdotes and interesting videos and memes—all while remaining relevant) (Y3-S1-2020).

Providing content in multiple forms assisted the students to visualise concepts (Baya'a & Daher, 2009).

As many students can be anxious about content knowledge in mathematics (Everingham et al., 2017), the content of the Moodle book was designed to develop students' content knowledge in small manageable amounts. This was successful according to one student:

> I am very nervous about my understanding of concepts. This course offered in-depth knowledge for each of the learning areas of the mathematics curriculum that I can use for future teaching (Y3-S1-2023).

Students showed a belief that the course developed knowledge of the content,

> by the end of the unit, I come away with a sense of accomplishment, confidence and competence to engage students with mathematical concepts (Y3-S1-2019).

Other students also shared satisfaction that the course materials were useful for the classroom*:* "So many classroom-based resources and tools. A lot of sharing of cool games and visual aids will be so helpful for me as a beginner teacher." Preparation for employment through engagement in course content was a positive outcome for these students.

Redmond et al. (2018) suggested that an indicator of cognitive engagement is student reference to the praxis connection of their learning in the course; that is, when students discuss how they will use learnings from the course—or the course content—in their discipline practice (in this case teaching), or discuss how they have applied it to practice or to other learning contexts. These examples arguably demonstrated their ability to connect their learning and its future application to practice (Everingham et al., 2017). The redesign of the course increased participation in the course materials as identified by the learning analytics. While the analytics cannot tell if a student has comprehended the materials, they can show what was accessed. Course access for the modules in the first- and third-year courses ranged from 62.3% to 100%, with an average of all modules being 90.02%, higher than the average of 56.2% from prior to the redesign (Table 6).

Table 6

Learning Analytics Data Showing Percentages of Students Who Accessed Course Lecture Materials (Moodle Books) from 2020 to 2023 for Y1 and Y3 courses.

Y1 course	**S1 2020**	**S2 2020**	**S1 2021**	**S2 2021**	**S2 2022**	**S3 2022**	**S2 2023**	Total
Module 1	100%	98.6%	98%	97.2%	98.7%	100%	98.3%	98.69%
Module 2	97.8%	98.6%	95.3%	91.5%	100%	97.3%	97.5%	96.86%
Module 3	100%	97.1%	96%	88.7%	96%	95.9%	97.5%	95.89%
Module 4	97.8%	97.1%	92.6%	87.3%	97.3%	94.5%	96.7%	94.76%
Module 5	95.76%	95.7%	85.9%	85.9%	97.3%	93.2%	94.2%	92.57%
Module 6	95.76%	94.3%	91.9%	78.9%	96%	93.2%	90.9%	91.57%

Module 7	95.76%	94.3%	85.9%	78.9%	94.7%	91.8%	90.9%	90.32%
Module 8	95.76%	92.9%	77.9%	78.9%	93.3%	91.8%	92.6%	89.02%
Module 9	95.76%	92.9%	79.9%	71.8%	92%			86.47%
Module 10	95.76%	92.9%	72.5%	71.8%	92%			84.99%
							Average Y1	92.11%

Y3 course	**S1 2020**	**S1 2021**	**S3 2021**	**S1 2022**	**S3 2022**	**S1 2023**		**Total**
Module 1	100%	95.2%	98.5%	90%	99%	98.4%		96.85%
Module 2	88.7%	96.4%	93.9%	95%	92.8%	92.2%		93.17%
Module 3	90.6%	89.2%	92.4%	87.5%	88.7%	90.6%		89.83%
Module 4	79.2%	92.8%	93.9%	87.5%	86.6%	89.1%		88.18%
Module 5	90.6%	84.3%	89.4%	75%	80.4%	89.1%		84.8%
Module 6	62.3%	92.8%	92.4%	82.5%	78.4%	92.2%		83.43%
Module 7	86.8%	85.5%	83.3%	72.5%	90.7%	93.8%		85.43%
Module 8	64.2%	77.1%	80.3%	75%	79.4%	92.2%		78.03%
							Average Y3	87.47%
							Average all modules	90.02%

Assessment in the redesigned courses focused on preparing students for teaching and learning in the classroom upon graduation, which was noted by a student; “The assessment felt relevant to the profession of teaching” (Y1-S2-2022). Assessment tasks aligned with the course content and provided scaffolded opportunities to engage in content knowledge and hands-on mathematics activities, even online: “I have enjoyed the 3rd assignment and found it quite useful as an interactive assessment to develop knowledge on the concepts covered but also my academic writing and referencing over the course of the semester” (Y1-S1-2021). Surprisingly only four negative comments were received about assessment workload, an improvement from 26/34 negative assessment comments in the course survey reports in 2017, prior to the redesign. This may be in part because “Our assessment pieces are broken up into smaller workloads for each week, with both peer and examiner feedback to help direct and improve our understandings and overall abilities” (Y1-S2-2022). Ensuring course content and assessment were provided in manageable workload portions appeared to be a positive aspect of the course redesign.

Interestingly deeper readings were included in the design of the third-year course. Less than a third of students accessed these resources over five offerings (Table 7) and there was no mention of the deeper readings as positive or negative in the course survey reports. Despite these findings, deeper readings have remained in the course as they provide a resource to the students who may want to access for consolidation of course content.

Table 7

Learning Analytics Data Showing Percentage of Students Who Accessed Deeper Readings 2020 to 2023 in Y3 course

Y3 course	S1 2020	S1 2021	S3 2021	S1 2022	S3 2022	S1 2023	Total
Deeper readings	24.5%	30.1%	37.9%	30%	39.2%	17.2%	29.81%

The results from the analysis of the high engagement in the course content identified in the learning analytics and the large number of data references in the course survey reports indicate that cognitive engagement in the course is highly valued by students.

Behavioural Engagement

Behavioural engagement was coded for 106 references from the 23 courses. The most powerful theme to emerge from these comments was the perceived value of the course design/structure on students' learning and engagement. "I appreciated the way so much effort was given to design" (Y3-S1-2020). Similarly another student said, "the best aspects of this course was the clear instructions and course design" (Y3-S1-2018). Almost half of the comments about behavioural engagement (52) related to the theme "course structure" with 10 references from the first-year course and 11 from the third-year course mentioning layout. A first-year student commented, "thank you for making something I was dreading into something easy to navigate" (Y1-S1-2020); another was more specific, "the setup and layout of completing modules were easy to use and found it to be of great benefit when being engaging with course" (Y1-S2-2021). A more experienced student expressed a similar sentiment: "the layout, both visual and practical has been the best in my 8 years studying with [university]. I would love it if other courses followed suit with how the course page, modules etc are set up" (Y3-S3-2018). Other students indicated that the way the course design enabled behavioural guidance through the course, "each topic was layout in a manner that could be easily progressed through" (Y1-S2-2019). Indeed, research supports the students' statements that a well-designed virtual classroom can support students' active engagement in learning, while a poorly designed LMS can hinder engagement (Rubin et al., 2010).

A sub-theme of course structure was students' value for the course being "self-paced." "It was extremely helpful having the course material available for online students to work at their own pace" (Y1-S2-2018). The modules were designed "into ten separate modules which could be undertaken at our own pace so we could arrange our life around prac and other requirements" (Y3-S1-2018) which "made working through the content at your own pace to get ahead when convenient for your study pattern" (Y3-S1-2019). Flexibility is particularly important in the online learning context, where many learners choose to study in this mode for its flexible nature (Stone et al., 2019).

Directed navigation from the course examiner was also identified as helpful. "[The course examiner] was fabulous at guiding me through the learning and provided extremely helpful and friendly feedback during the course*"* (Y3-S3-2018). Table 8 outlines a number of behavioural initiatives that were included in the course redesigns. The Getting Started section contained information about the course and how to engage in the course for success. There were no comments specifically about the Getting Started section in the course survey reports, and the completion of the Getting Started activities ranged between 48.3% and 91.3% in the first-year courses and 42.4% and 72.5% in the third-year courses, indicating a wide disparity between the courses and offerings.

Announcements on a weekly basis guided students in their study and provided students with the tasks to do in one week. Announcements would be uploaded onto the LMS on a Monday morning and would also be automatically sent to the students' university email. For students, this meant "the weekly breakdown and learning was easy to understand, find and navigate online" (Y1-S1-2018). Weekly emails were accessed slightly more by first-year students, with an average of 74% as compared to 63.83% of third-year students (Table 8).

Table 8

Learning Analytics Data Showing Course Elements Coded as Behavioural from 2020 to 2023 for Y1 and Y3 courses.

First year course	S1 2020	S2 2020	S1 2021	S2 2021	S2 2022	S3 2022	S2 2023	Total
Getting Started	58.7%	48.3%	91.3%	58.3%	86.7%	89%	72.7%	72.14%
Announcements	67.4%	75.5%	81.9%	73.2%	69.3%	89%	62%	74.04%
Course Examiner tips	93.5%	48.3%	40.3%	85.9%	26.7%	26%	14.9%	47.94%
Step by Step guide to assessment	93.5%	85.3%	99.3%	95.8%	92%	95.9%	95%	93.82%
Total	78.28%	64.35%	78.2%	78.3%	68.68%	74.98%	61.15%	71.99%

Third year course	S1 2020	S1 2021	S3 2021	S1 2022	S3 2022	S1 2023	Total
Getting started	64.2%	62.7%	42.4%	72.5%	52.6%	45.3%	56.61%
Announcements	64.2%	60.2%	71.2%	62.5%	57.7%	67.2%	63.83%
Step by Step Guide assessment	98.1%	97.6%	100%	97.5%	100%	98.4%	98.6%
Total	75.5%	73.5%	71.2%	77.5%	70.1%	70.3%	73.01%

Step-by-step guides were developed to provide students with clear instructions about how and what was expected to be included in the assessment, along with links to resources that would help them in the course content (e.g., referencing tools). Students stated: "the step-by-step guides for the assignments were incredibly helpful (Y3-S1-2019) and one of the best things about this program is how well scaffolded the assignments were" (Y3-S1-2019). This is evidenced by approximately one fifth (n=18) of comments pertaining to the usefulness of the step-guide, and the highest access by students of all materials on the LMS, averaging at 93.82% in the first-year course and 98.6% in the third-year course. Fanshawe et al. (2020) indicated that providing early access to support and stating specific expectations are likely to enhance student engagement. A first-year student explained, "the clear step-by-step guide of the assessment made it a lot easier to understand what was required" (Y1-S2-2018). Students indicated that the step-by-step guides helped them to succeed: "the scaffolding provided for the assessments was appreciated and allowed me to prepare high quality submissions" (Y3-S3-2018). The guides were also designed to increase students' confidence:

> Each task was stepped out very explicitly leaving no room for guessing. It was also great how it had the relevant part of the rubric next to the step of task description to help you focus in on what was required (Y3-S1-2019).

This comment indicates that the step-by-step guide helped the student feel confident they were meeting the assessment criteria. Additionally, the step-by-step guides were designed to support development of the assessment throughout the course: “I loved that I could stay on track easily with a weekly task, making finishing before the assessment due dates stress free” (Y1-S2-2020). Wanner (2014) argued ongoing assessment rather than leaving it to the last minute is crucial for student success.

A final theme and consideration in the course redesigns was the use of “badges.” These are digital awards presented to students in the virtual classroom upon completing specified tasks (Fanshawe et al., 2020). Comments which related to the use of the badges (n=17), reinforced their value for tracking learning progress and motivating students. As a first year student shared, “I liked that the badges showed when you had completed all requirements for a topic” (Y1-S2-2019). Third year students also thought “the badges were a great way of tracking my progress” (Y3-S1-2019). Dowling-Hetherington and Glowatz (2017) found that badges were a type of gamification which could be used to encourage students to achieve desired educational outcomes. This was supported by student comments: “receiving badges was a good motivator (Y2-S2-2020). We got badges and emails to encourage us to keep going with the course (which surprisingly worked!)” (Y3-S2-2018). That is, the badges helped to shape students’ learning behaviours. These comments indicated that behavioural elements in the course were valued by students.

Collaborative Engagement

Collaborative engagement was coded for 50 of 451 references from the 23 courses. While collaborative engagement items made up only a small percentage of the codes, tutorials, forums and a meet-up leader were identified as valued for collaborative engagement in the courses. Tutorials on Zoom included a joint problem, or hands-on maths activity that students had to work with others to achieve “A really collaborative and productive environment” (Y1-S2-2021). Students reported “Tutorials are a great time to collaborate with colleagues and talk over the content for the week” (Y1-S1-2023). As students met regularly, they had a familiar group of peers in tutorials which made the information, activities and brainstorming so much more comfortable and valuable (Y1-S2-2021). Despite students reporting the usefulness of tutorials on Zoom, attendance numbers remained low across both year levels, with first year participation ranging from 21.7% to 55.9% and third year from 35% to 66% (Table 9). To ensure all students were able to have collaborative activities, forums were designed as a way to contribute asynchronously to conversations about the course. Forum participation ranged from 62% to 89% in the first-year course and 82.5% to 94.3% in the third-year course.

Table 9

Learning Analytics Data Showing Course Elements Coded as Collaborative from 2020 to 2023 for Y1 and Y3 Courses

First year course	S1 2020	S2 2020	S1 2021	S2 2021	S2 2022	S3 2022	S2 2023	Total
Tutorial on Zoom	21.7%	55.9%	38.3%	33.8%	*	*	*	37.43%
Forum participation	67.4%	75.5%	81.9%	73.2%	69.3%	89%	62%	74.04%

Third year course	S1 2020	S1 2021	S3 2021	S1 2022	S3 2022	S1 2023	Total
Tutorial on Zoom	66%	50.6%	56.1%	35%	47.4%	37.5%	48.77%
Forum participation	94.3%	81.9%	93.9%	82.5%	87.6%	84.4%	87.43%

*Access to Zoom links were not recorded in course analytics for these offerings.

Forums were valued by students both as "a great way to see other students' perspectives, analyse ideas and make connections" (Y1-S3-2021) and because "the activities we have to complete for the forums are fun and engaging" (Y1-S1-2023). Participation in forums increased students' belief in their ability as they worked with their peers: "I loved being able to participate so much throughout the course. As daunting as the forums initially were it was a great way to learn from my fellow peers and even gave me some great ideas for my future role as an educator" (Y1-S2-2018). The preference to interact asynchronously by students in both courses was perhaps due to the time-poor nature of our students and their need to balance their higher education learning with family, work, and other tasks (Burke & Fanshawe, 2024).

One initiative implemented in the third-year course was using a *meet-up leader* who ran one tutorial per week. Meet-up leaders were members of course teams who had previously completed the course and were paid to tutor groups of current students in the course content through a peer-to-peer process. As the course is about mathematics, the meet-up leaders were employed to coordinate tutorials and work one-on-one with students who felt they wanted extra help with the course's mathematical concepts. The feedback from students who attended these sessions was positive. For instance one participant "loved having a past student to be able to contact and discuss the course and assessment" (Y3-S1-2021). Students reported that the meet-up leaders helped them increase their understanding of the concepts being taught in the class, thus reducing some of their anxieties around mathematics. Research (e.g., Kimmins, 2013) suggests that peer tutorial programs such as Meet-Up have positive benefits on confidence, by connecting students with someone who has successfully navigated the course (Redmond et al., 2018).

Emotional Engagement

Emotional engagement was coded for approximately one third of the references (n=143) from the 23 courses. Two main themes emerged from the student comments relating to emotional engagement. The first of these was related to positive relationships and emotional connections with the course examiner, and the second was a positive disposition towards the course and the content upon completion.

Emotional reactions of and to others in the course were indicators of emotional engagement (Redmond et al., 2018). Comments from 48 data references highlighted that the "enthusiasm" and "positive attitude" displayed by the facilitator were valued and that this helped them to connect emotionally with the course: "[The course examiner] created a positive and exciting atmosphere every class and made learning about maths very exciting!" (Y3-S1-2019). Research indicates that, although enthusiasm is an individual quality of a course facilitator, "positive emotions can facilitate activation of attention and engagement" (Sinatra et al., 2015, p. 2). This means that university educators need to be aware of how their attitudes can impact

students' engagement in an online course. Furthermore, emotion is also "important to student adjustment to the role of online learner" (Cleveland-Innes & Campbell, 2012, p. 272).

Mentioned by 37 students, the support of course facilitators impacted how students perceived the course. The comments indicated that students felt the teacher cared for their learning and well-being, which in turn impacted how they participated in the course (Burke et al, 2022). "[The course examiner] was supportive …and personally emailed me to congratulate me on my marks and offer her support … this made me keep going" (Y1-S2-2018). Others indicated that they felt they were getting quality learning due to the care presented by the course examiner*:*

> I greatly appreciated her emails checking on students' understanding of the course and assessments, you do not get these from many lecturers but you could tell she truly cared about her students and wished to provide the best education to them as possible (Y3-S1-2019).

Interestingly, strategic use of inbuilt technologies helped to give students the impression that the course examiner knew how every student was performing. For example badges, although implemented in the course as a behavioural guide, also made students feel "as though she really cared about how I was tracking throughout the course" (Y3-S1-2019). Connecting with students and regular positive contact can provide interaction for students to find belonging (Burke & Lamar, 2021) as evidenced by a first-year student: "studying online can be lonely but [examiner] made us feel very much a part of her course and was really supportive" (Y1-S2-2018). Thus emotional connection, although personal for each course examiner, should be considered in the design to provide opportunities for students to feel belonging in their course and program (Cleveland-Innes, & Campbell, 2012).

From the data analysis, it was clear that students had emotionally engaged with their courses. For some students, an outcome of that engagement was a change in attitude towards mathematics: "I found that the course was almost designed for enjoyment and to change our (students') view of math. And it truly did" *(*Y3-S3-2018). Other students described indicators of emotional engagement that suggested they valued learning, acquired knowledge and skills, and appreciated success. The emotional engagement element has been explained as related to positive and negative attitudes toward learning and content (Sinatra et al., 2015). In courses where the content traditionally makes students anxious, then positive engagement may arguably be demonstrated by a change in attitude, such as a willingness to engage with materials that were previously viewed negatively or considered difficult. Many students described a change in attitude towards mathematics due to taking the courses: "I had maths anxiety going into the course but this quickly resolved with the way the content was taught and the support offered throughout. By far one of my favourite courses so far" *(S1-S2-2020).* These findings suggest that emotional engagement and support for students plays a fundamental role in online engagement.

Social Engagement

Social engagement was coded for 30 of 451 references from the 23 courses, representing less that 10% of data. Feedback on the aspects of the course that were designed to encourage social engagement was mixed, as was participation. Social forums in the third-year course, designed to have asynchronous conversations not related to course content, had an average

participation of 58.55% of students. In the first-year course, a catch-up session was offered in 2020 and 2021, designed to check in on students socially. As fewer than 20% of students attended any of the catch-up sessions, the catch-ups were removed from the course and social forums were introduced with an increased participation rate of 57.53% (Table 10). Low attendance at catch-ups indicated that students may prefer to connect online rather than in person, or it could have been related to COVID-19.

Table 10

Learning Analytics Data Showing Course Elements Coded as Social Engagement from 2020 to 2023 for Y1 and Y3 Courses.

First year course	S1 2020	S2 2020	S1 2021	S2 2021	S2 2022	S3 2022	S2 2023	Total
Catch up	15.2%	16.2%	19.8%	-				17.07%
Social forum					61.3%	65.8%	45.5%	57.53%

Third year course	S1 2020	S1 2021	S3 2021	S1 2022	S3 2022	S1 2023	Total
Social forum	45.3%	56.6%	74.2%	55%	60.8%	59.4%	58.55%

Although some students found that these aspects supported their learning through "having an enjoyable conversation with peers" (Y3-S1-2023) or just to have social contact to "stay engaged with other peers" (Y1-S-2018). Six of the 32 comments were negative, relating to students wanting to have social chats in tutorials rather than learn, or commenting that social forums were "not effective teaching tools and do not have much educational value" (Y3-S1-2018). These findings suggest that the social aspects are elements that still might be improved; however, at the same time, they may be indicative of a general malaise that many students show for social or collaborative aspects of courses (Krishnan, 2016).

A final word cloud (Figure 5) was produced by NVIVO, which included the top 50 words used in the course survey reports. The word cloud identified high frequency words, resulting in course, learning, tutorials, teaching, lecturers, assignments, students, engagement, assessment, and content as the 10 most frequently used words by students to describe their perceptions of what they valued and did not value in their course.

Figure 5

A Word Cloud Generated by NVIVO from Highest Frequency of Words in Course Survey Reports.

These words reiterate the high student satisfaction from students who have been engaged in the redesigned courses, and offer the possibility that the OEF can play an important role in redesigning online courses with student engagement in mind.

Conclusion

This paper has provided an overview of the design experiment method (Cobb et al. (2003) and used the OEF in Higher Education (Redmond et al., 2018) to audit the effectiveness of a first- and third-year course in the School of Education at a regional Australian university. Several recommendations are provided as a result of redesigning the courses using a design experiment methodology. First, improving ITE courses, and more generally higher education programs, begins with ensuring the students have engaging online learning environments to learn content that will prepare them for employment (Martin, et al, 2018). As shown in the results of this study, it is not just the cognitive content that students value, but also behavioural aspects of the course, and the emotional connection to the course and the content. Additionally, collaborative and social engagement, while shown to a lesser degree, were important to course participation and engagement for students in this study.

The second recommendation is to prepare university teaching staff with the knowledge and skills to design online higher education courses, with a valuable tool being referencing and utilising a framework to inform practice, such as the elements of the OEF. This paper illustrates how using the OEF as an audit tool enabled critical thinking and reflection on evidence and gaps in relation to different ways in which engagement was integrated into the design of courses. These insights thus helped refine the courses further in the redesign by integrating new elements to augment particular elements of engagement. The results indicating the course redesign increased course satisfaction across the courses over 23 offerings.

The authors acknowledge that while the paper presents results from a single case study from one regional university in one type of course (i.e., ITE mathematics course), details of the methodological process and redesign are insightful in offering knowledge of arange of engagement elements (cognitive, behavioural, emotional, social, and collaborative) in the redesign of courses. Future research could investigate the impacts of engagement-focused design on other courses. The paper highlights that for tertiary educators, the Online Engagement Framework for higher education was of value as a tool for examining how courses stimulate online student engagement, systematically designing how engagement might be enhanced, and evaluating how each element was valued by online higher education students.

Declarations

Ethical approval was gained from the University of Southern Queensland Human Research Committee approval # ETH2020-0100 and ETH2023-0847.

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