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Bend me, stretch me: Connecting learning design to choice

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Active and interactive learning approaches in course design are widely supported as increasing student engagement and learning outcomes in blended or technology-enhanced environments. As such, designing for student engagement in self-paced distance and online learning environments is a growing area of research. However, learning is increasingly developed and delivered via the institutional LMS where the design and sequencing of content is linear and has an inherent directional flow. Learner choice in navigation and activity in online learning environments may also impact learner engagement but there is less research on these factors. In this research project, we evaluate the redesign and prototype of one week of a first-year business subject that offers learner choice in navigating the online environment and choice of activity. Insights into the innovative educational design and implementation of non-linear and interactive learning are presented within an Australian higher education business context, where flexibility and choice emerge as key design affordances.

Keywords: learning design, online interactive learning, non-linear, student engagement, higher Education

Introduction

Active and interactive learning approaches in blended or technology-enhanced course design are widely supported as increasing student engagement and learning outcomes, along with other contextual factors (Castaño-Muñoz, Duart, & Sancho-Vinuesa, 2014; Pye, Holt, & Salzman, 2018; Tamim, Bernard, Borokhovski, Abrami, & Schmid, 2011). Analysis from a national study of first-year student engagement also suggested online engagement and its impact on learning could be understood in part by its promotion of independent and self-initiated learning (Krause & Coates, 2008). Designs which provide opportunities for learner control and self-direction in online self-paced courses increase learner engagement and such learners are more likely to successfully complete their courses (Lim, 2016). While there are some studies that investigate learner choice and autonomy as an affordance in student engagement in self-paced distance and online learning environments in the higher education sector (Ranieri, Raffaghelli, & Pezzati, 2017; Robinson & Hullinger, 2008), there is a paucity of research about how students might choose their own pathway through learning content and activity. Within the available literature, student interaction is studied in self-paced online modules with a prescribed learning sequence (Christensen, Kjær, & Hansen, 2018), a linear release of modules as per course flow (Dhaliwal, Simpson, & Kim-Sing, 2018), or as a choice of order of completion of all online modules within a self-paced course (Ranieri et al., 2017). Other research examined the potential of adaptive technologies, intelligent tutoring and recommender systems in blended learning, noting that such technologies are not always appropriate "where knowledge is less stable and standardized" (Castro, 2019, p. 2541).

The purpose of this paper is to explore learner choice in an online learning environment that is part of a blended learning subject. Specifically, this research explores:

1. How do students choose to traverse through a non-linear and interactive online learning environment?
2. Does designing for non-linear learning online encourage learner choice and learner engagement?

Background and context

This paper discusses a large cohort first-year subject within an undergraduate business degree at a large metropolitan Australian university, which underwent an extensive re-design in 2017. As a result, content in the subject is current and reflects global megatrends and contemporary business thinking. However, the subject's delivery still followed a traditional model of student engagement via lectures and tutorials, which needed redesigning with scalable 21st century pedagogies to meet the tremendous growth in enrolments at the university.

In the semester of this study, the subject had a large diverse cohort of both domestic and international students. The prior experience and knowledge levels of business concepts varied widely amongst the cohort. As such, it was important to offer students choice within the learning content. Students who needed more support could have opportunities to practice skills and concepts, while capable students could take advantage of extension activities to stretch their knowledge.

The redesign of this subject was instigated by the overall course review of a broader project titled Connected Learning at Scale (CLaS). CLaS is a university strategic project aimed at transforming teaching and learning in large core subjects of Business School programs, leveraging the affordances of technological innovation (Vallis, Bryant, & Huber, 2019). Its principles build on learning theories that propose learning design that is active and self-directed in accordance with constructivist and connectivist theory, as opposed to more traditional teaching designs and methods where learning is characterised by consumption of expert knowledge (Baeten, Kyndt, Struyven, & Dochy, 2010; Ertmer & Newby, 2016; Laurillard, 2009; Siemens, 2005). Learning in authentic and situated contexts, creative problem-solving, critical thinking, team collaboration, and the ability to manage and communicate complexity are valued more highly than traditional university teaching where content is provided for students to master and reproduce (Bennett, Harper, & Hedberg, 2002; Davis & Sumara, 2009; Matthews & Wrigley, 2017). From such broad learning theory, the project has distilled the three principles below:

1. *Information engagement*—students individually and collectively engage with discipline knowledge as opposed to having it broadcast at them in a lecture.
2. *Connected participation and active learning*—teaching and learning activities and technology are leveraged to build connections and networks to address, debate and solve critical global and local challenges.
3. *Relevant and authentic assessment and feed-forward*—learning is applied and tested through authentic or real-world assessment modes supported by opportunities to receive and share feedback from academics and their peers.

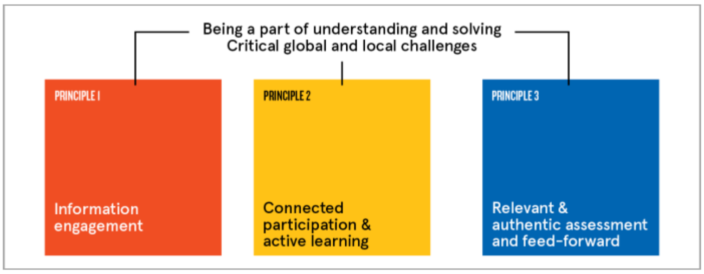

Figure 1: Connected learning principles

Prototype

The principle of Information Engagement was identified for prototyping a topic and formed only one outcome of a holistic re-design of the course described above. With the support of a multidisciplinary team of educators and design staff, the lecture of one week of the subject was redesigned and implemented as an interactive online prototype (hereafter referred to as the prototype) to complement and extend the face-to-face tutorial. The prototype’s topic was carefully selected to prototype a complete redesign of how students might engage with business discipline knowledge. Instead of the traditional lecture-transmission model, the lecture topic was redesigned so students could actively engage with discipline knowledge, receive instant feedback on self- directed learning activities, and have opportunities to interact with each other online.

Firstly, the prototype was designed to be flexible so students could choose their own path through their learning, and easily skip ahead or return to areas of interest or need. User-directed features for learners in the prototype were prioritised (Firat, Sakar, & Kabakci Yurdakul, 2016). The topic was redesigned into smaller discrete sub- topics that could be learnt in any sequence to increase learner control and engagement with content. These subtopics were to be delivered in a non-linear format on the University’s learning management system (LMS) Canvas, where typically learning is in a pre-determined teaching and learning sequence.

The homepage of the prototype was designed to reduce extraneous cognitive load and focus learner attention on the sub-topics by maximising white space and minimising distraction (Sweller, Van Merrienboer, & Paas, 1998). Sub-topics were presented as series of squares of different colours and sizes, with stars placed in the squares to indicate the page as a minimum requirement. The larger squares, combined with the stars, visually signalled key concepts. In total, eight pages were starred as a minimum: ‘Introduction’, ‘Review’ and the six ‘Learn’ pages.

Students could access the squares in any order and at any time of the week. They could also choose not to visit topics, although they were encouraged to complete the starred pages at a minimum. Content was also grouped according to colour, although all pages were designed as stand-alone content. Students could choose their own pathway through the content and activities which were aligned and sequenced to support self- directed learning, application and current debate in real-world contexts (Bennett et al., 2002). See Figure 2.

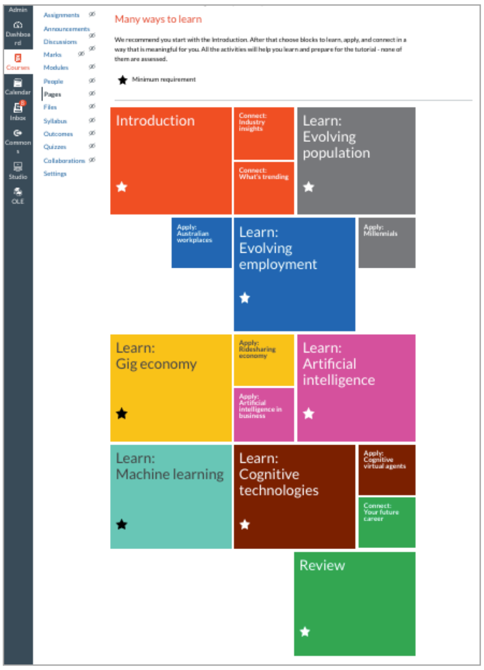

Figure 2: Homepage of the prototype

Subtopics in the prototype were designed to be multi-modal. Students interacted with different activity types, including video, cases, conversations, debates, lectures, worked examples, and applications. Short videos of academics and industry experts explaining topics and concepts created a sense of teacher presence in the prototype (Garrison, 2007). Interactive activities primarily checked students' understanding of the learning content (quizzes, drag and drop activities and summaries), facilitated peer-to-peer connection (polls and online bulletin boards), promoted reflection (open-ended text boxes) or encouraged students to apply and discuss concepts and frameworks (online bulletin boards and a discussion forum). Complex business information was schematically represented for clarity and students could choose to interact with diagrams for more detail, including text, rich media and links (Hollender, Hofmann, Deneke, & Schmitz, 2010). To encourage students to engage with each other beyond the boundaries of the LMS and university, a page titled 'Connect: emerging trends' was designed with embedded Instagram feeds, suggested pathways and connecting more broadly to business communities of practice (Veletsianos, Kimmons, & French, 2013).

Student interaction with the prototype was not compulsory, just as lecture attendance and/or viewing lecture recordings was not compulsory. Rather the prototype was flagged as a new way of engaging with content in preparation for tutorials with formative feedback as a means of checking their progress. Students could choose their own learning sequence and traverse activities and content according to their own perceived needs and interests.

Method

Research was conducted on the prototype as an intervention for practical and theoretical insights (McKenney & Reeves, 2018). The design, development, implementation and evaluation of learning activities and content were conceptualised as a rapid prototype to inform future iterations through actionable insights in three development phases. Prototyping is commonly used in educational technology research which focusses on the usability of educational applications (Mwandosya, Suero Montenero, & Mbise, 2019; Santos et al., 2014).

The primary source of data discussed in this paper is navigation analytics from Canvas log files and learner interaction data from third-party interactive authoring tools, collected one month after the prototype was launched. Data from 448 student participants was analysed and used to understand how students move through the material in Canvas (including order of pages, return page visits, typical pathways) and the extent to which they engage with various interactive activities, including videos. User navigation data in Canvas was joined with student demographic data and analysed with the aid of a data visualisation in a custom dashboard (generated by Power BI). Visualising the data assisted pattern recognition of page data at scale, with students visiting 28,085 pages in 603 sessions.

The data was analysed for patterns of engagement with the prototype in order to assess its learning design features and to inform future iterations. Data was not used to predict a model or mine student data in order to intervene or suggest recommendations for student learning, rather focusing on data related to learners' interactions with course content to improve learning design of the prototype (Avella, Kebritchi, Nunn, & Kanai, 2016). This study had ethics approved by the University of Sydney, [approval no. 2019/892].

Learner data from third-party tools was collected to analyse students' engagement with interactive activities. Video statistics were collected to compare with views and download data for lecture recordings in other weeks. Most interactive content was created in H5P.com and integrated with Canvas via LTI. Other third-party tools were used to encourage social learning via polls and an online bulletin board. Interaction data was drawn from the following third-party educational software:

- Video: Vimeo (number of loads, plays, views, finishes and average watched)
- Interactive authoring tool: H5P (count of unique users, average number of attempts, average first score, average best score)
- Social polling tool: Opinion Stage (number of votes)
- Online bulletin board: Padlet (number of posts and upvotes)
- Discussion forum: Canvas (number of posts and likes)

Data was collected from interactive presentations from two different content authoring tools but was not analysed and compared with the above data due to inconsistent metrics across platforms. Also essay-style questions where students were prompted to enter reflections in textboxes did not generate reports that could be analysed as data was not saved in this activity type.

Additional qualitative data was collected to triangulate the quantitative data (Creswell, 2016). Qualitative comments were drawn from the survey students complete online in the final weeks of semester that relates to feedback on their student experience at the subject level (n=213). The open student comments from the survey results were then thematically summarised (n=159).

Results

User navigation

A total of 499 students were enrolled in the subject at the time the prototype was launched. A majority (89.8%, n=448) of the cohort accessed the prototype site. As expected, the most visited pages were those starred as minimum requirements, which includes the 'Introduction' and 'Review' pages, and all 'Learn' pages. These pages were also the largest blocks in the grid on the homepage. The pages marked as 'Apply' and 'Connect', which were visually less prominent, were visited least. Many students chose not to visit every page and 34 students (7.6%) only visited the homepage.

There were minor differences in patterns of page access between international and domestic students. Most students visited 'Introduction' which outlines the learning outcomes for the week, readings, and has a short video in which the teacher introduces the topic and concepts. On average, international students visited the 'Introduction' and 'Learn: Gig economy' pages (represented in black and red in Figure 3) more often than domestic students. Domestic students also visited the 'Review' page more frequently (13.7%) than international students (7.8%).

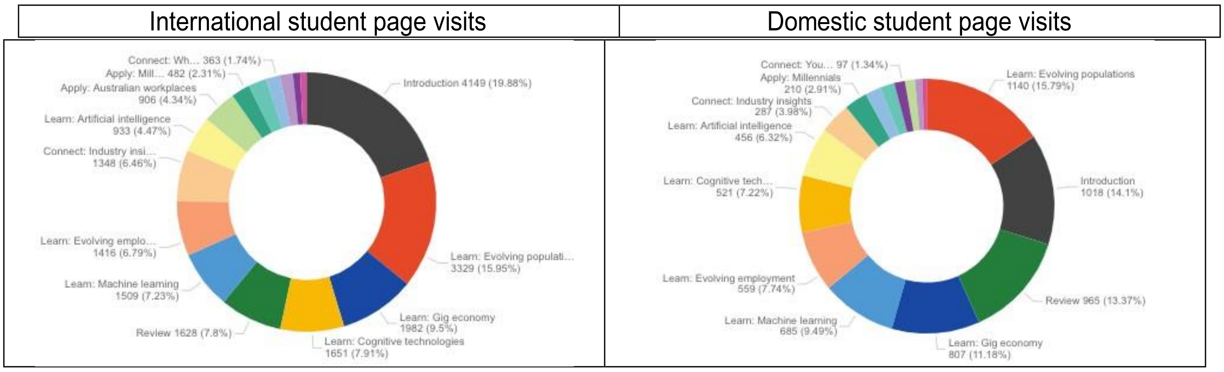

Figure 3. Total page visits by domestic or international students

However, the most significant difference in navigation was by gender. One student chose not to specify gender. On average females most frequently visited the 'Learn: Evolving populations' (19.89%) and 'Introduction' pages (17.15%), represented in red and dark grey in Figure 4. By contrast, males visited 'Introduction' (20.58%) and 'Review' (10.82%) pages most frequently (represented in dark grey and green). The next three pages visited most on average were evenly distributed between 'Learn' pages. Females were also more likely to visit all pages starred as a minimum (35.32%) compared to males (27.07%).

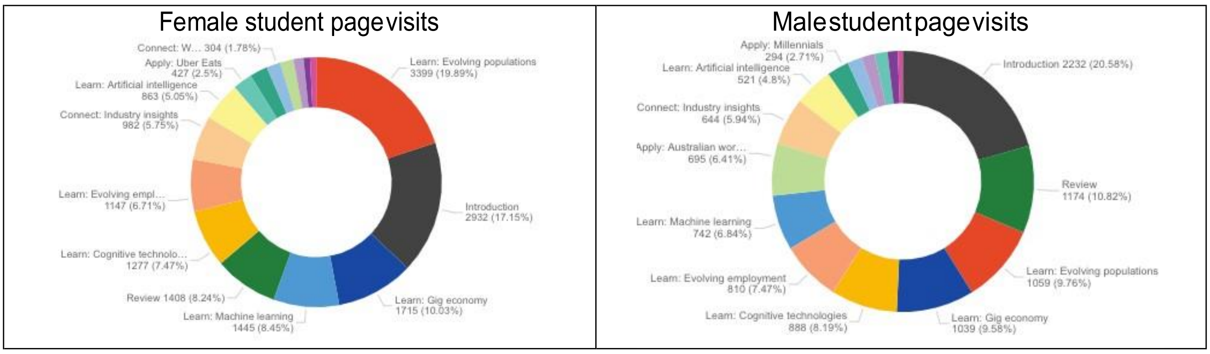

Figure 4. Total page visits by gender

Figure 5 shows a sunburst visualisation of students' navigation paths one month after the prototype was launched and demonstrates a great diversity in the way students chose to engage with learning content (838 different paths). The first ten pages visited in a session are visualised in the diagram. Each coloured block represents a page visited.

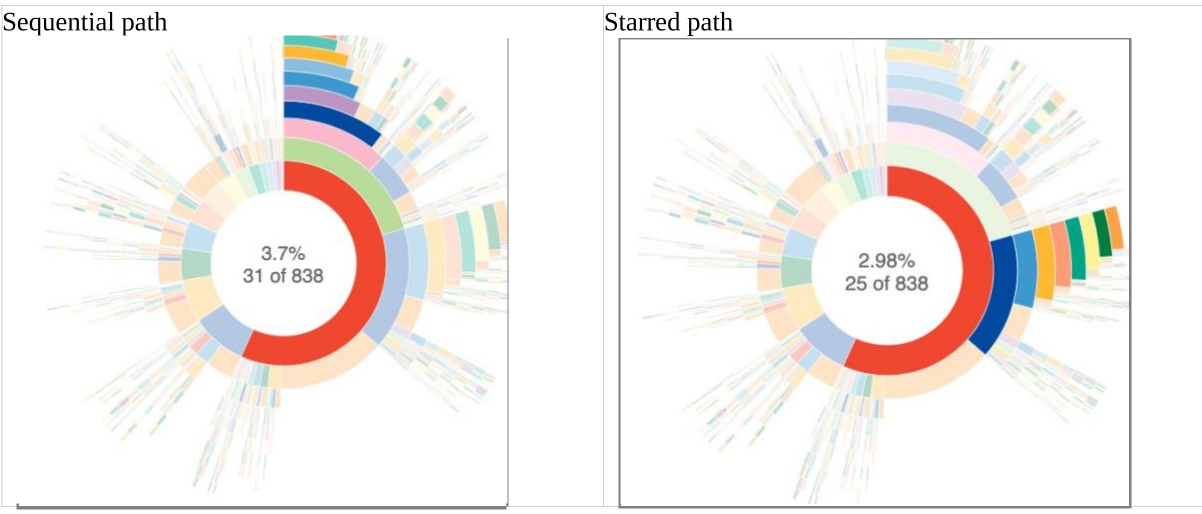

Figure 5: Diagrams of two most common navigation paths

The two most popular ways of navigating through the learning content are highlighted. Two-thirds of students (75%, n=338) chose to access the introduction page as recommended on the homepage but then how students navigated their learning differed greatly.

The most popular learning paths involved navigating sequentially or by perceived importance (starred pages), as highlighted in the sunburst visualisations (see Table 1). Yet each of these paths accounted for only 3.7% and 2.98% of students respectively.

Table 1. Order of pages visited

Page visited by order	Sequential path (Page title)	Starred path (Page title)
1st	Introduction	Introduction
2nd	Connect: Industry Insights	Learn: Evolving populations
3rd	Connect: What's trending	Learn: Evolving employment
4th	Learn: Evolving populations	Learn: Gig economy
5th	Apply: Millennials	Learn: Artificial intelligence
6th	Learn: Evolving Employment	Learn: Machine learning
7th	Apply: Australian Workplaces	Learn: Cognitive technologies
8th	Learn: Gig Economy	Review

Interaction data

The prototype's introduction video was the most played (n=235) and had the greatest number of finishes (n=162), while the other two learning content videos had fewer plays (n=130) and subsequently fewer finishes. The lengthiest video, at over seven and a half minutes, had the least amount of finishes (n=53). However, the average percentage of the videos watched was similar with a range between 78 and 83%. By contrast, student engagement with lecture recordings decreased sharply as the weeks progressed. For example, in the previous semester, the highest number of lecture recording views was in the third week at 823, which measures access, but the finishing rate was only 9.7%. On the other hand, students who attended the lecture in-person may not have needed to access the lecture recordings. Hence video data is not included in discussion of the interaction data below.

Activities where students were asked to contribute comments (discussion forums and online bulletin boards) had minimal engagement. The Canvas discussion had the least interaction (n=2%). However, social polling activities had comparatively high engagement. In fact, a social poll that asked students how they thought business might be impacted by changing demographics had the most interactions (n=90%) compared to the number of students who accessed the page on which it was embedded.

Generally, engagement with quizzing activities on H5P mirrored unique student views of each page (see Figure 6). On average, two thirds of students who accessed a page interacted with the activity. Approximately one third of students engaged with all interactive activities available. In three out of the six activities students achieved a score over 95% on their first attempt and hence most students attempted them only once on average. However, the drag and drop activities proved to be more challenging, with students receiving a score of 51% and 80% on their first attempt.

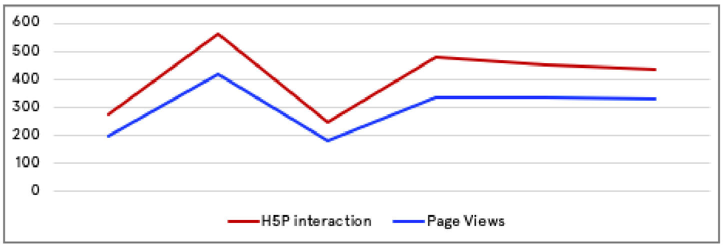

Figure 6: Interaction compared to page access.

Survey results

Results from the subject's end of semester survey do not indicate satisfaction or dissatisfaction with the prototype, with only four explicit comments. Two students indicated that the online learning was one of the best aspects of studying this subject. Three students offered suggestions for improvement. One student enjoyed learning with the prototype but also requested PowerPoint slides, while another student wanted even more examples of current real-life situations and interactive elements. Only one student commented negatively, stating they struggled with the structure of the prototype and found it unhelpful for teaching and learning.

Discussion

Prototyping proved a pragmatic choice, where design features to increase student engagement could be developed, tested and evaluated more rapidly than in longer research projects. Using data visualisation to analyse student navigation patterns also assisted greatly in identifying patterns of response to the learning design and challenging assumptions about how students choose to navigate their learning. However, wrangling data from different sources was time-consuming and difficult for a relatively small data set, and the process unsustainable as a long-term solution (Rienties, Cross, Marsh, & Ullmann, 2017).

The data studied in the prototype suggests that students took advantage of the flexibility and learner choice inherent in the learning design, with a great diversity in the way students chose to engage with the learning content. Despite the most popular learning paths being those marked as minimum requirement and sequential, these two paths only represented 6.68% of the total paths taken (n=838). Many students chose to progress non- linearly through the learning content which may indicate students directed and adjusted their online engagement in accordance with the types of autonomous learning skills that the design was intended to foster (Cho & Kim, 2013; Krause & Coates, 2008).

Furthermore, the most popular pages were those marked as a minimum requirement. In that sense, the learning design pattern of items labelled 'Learn, Apply, Connect', with a topic introduction and review page, allowed enough flexibility for students to choose their own path according to their own preferences and perceived needs, and the ability to check their progress and change path if necessary. Nor were students sequentially working their way through the pages marked as minimum requirements, as the overall second most visited page, 'Learn: Gig economy'.

The males in the cohort visited 'Introduction' and 'Review' pages most frequently, indicating perhaps a strategic approach to the use of their study time. By contrast, overall the female cohort tended to prioritise the 'Learn' pages over the 'Review' page. While other studies have examined gender differences in motivational and online environments, the data in this research cannot be interpreted as requiring different designs based on gender (Yukselturk & Bulut, 2009; Rovai & Baker, 2005). Rather different navigational paths may be an interesting discussion point for students and educators in terms of learning strategies. No one path is inherently more valuable than the other, but it is interesting to observe that students approach the prototype differently and to intentionally design flexibly for diverse student goals.

Learning via the prototype certainly required more self-direction and was a different experience to their usual attendance at lectures. The maturity of first-year students and their readiness to engage in learning in a self-directed way may be a factor. Research indicates that students typically develop critical thinking skills over the course of their degree or program, and tend to knowledge-acquisition strategies earlier on, which may partially account for some of the preference for lecture recordings and attendance (Lake & Boyd, 2015; Nordmann et al., 2019). The previous educational background of students and level of confidence are important to understand in student engagement with designs that offer more choice and self-directed learning (Ranieri et al., 2017).

Students' interaction with the prototype suggested the importance of the principle of designing for self-paced formative feedback in an online environment. Student engagement with the activities indicate that they valued opportunities to check their understanding of concepts while engaging with and reviewing discipline information (Hattie & Timperley, 2007). However, few interactive activities were attempted more than once as many students obtained the correct answer on their first attempt prompting a review to check if further refinement of the content may stretch and engage students more. The 'drag and drop' activities were more challenging with more attempts needed to place all terms in the correct category to be marked correct.

Interaction data yielded further learning design insights. As expected, activities in which students were required to contribute comments had the least engagement among all activity types. Students had no prior experience of discussion as a part of their learning in this Canvas subject, other than a forum that was used for general queries, and one week was too short to build a community of inquiry (Garrison, 2007). Contribution was also an optional formative activity and students may have flagged it as unnecessary to instead focus on other tasks. However, the data cannot account for students who "lurked" in activities and may account for some of the low response rate. The prototype was designed for learning by choice with multiple modes of engagement, so that students could still effectively learn by reading discussion forums and online bulletin boards, even if not directly and actively contributing for a variety of reasons (Bozkurt, Koutropoulos, Signh, & Honeychurch, 2020).

Moreover, the prototype appeared to complement the face-to-face tutorial and support a flipped classroom approach where class time could be reserved for debate and discussion, group work, problem solving and other collaborative teaching and learning strategies (Kim, Kim, Khera, & Getman, 2014; Abeysekera & Dawson, 2014). After the 'Introduction' page, the 'Learn: Gig economy' page was the most visited page, although it was visually positioned later in the design than other 'Learn' pages. The 'Learn: Gig economy' page was explicitly linked to an activity in the week's tutorial, which may indicate that students were using the prototype as intended to prepare or review their tutorials. Additionally, the popularity of the 'Review' page, and the multiplicity of navigational paths to it, indicate that students were using the page to check their progress against the learning outcomes and then return to pages to review content or practice activities. In more flexible, non- linear designs, it is even more important that students are able to monitor their own progress, and this is an area for development (Firat et al., 2016).

Limitations

Possibly, the multiplicity of learning paths was a sign of some students' confusion rather than of exploration and wayfinding. Yet there were no queries about the prototype in the subject's support forum, where students frequently asked questions. Additionally, results from the end of semester survey did not indicate satisfaction or dissatisfaction with the flexible design of the prototype, although the survey was administered at the end of semester, one month after their experience of the prototype which may have influenced student response (Backer, 2012).

Data around attendance, offline activities, social media and other informal online activity were not available to collect to consider alongside the prototype data so is representative rather than inclusive of all student engagement. Ethically, it would also be questionable to collect all digital traces of collaborative, creative and social engagement in learning even if that was possible (Wintrup, 2017).

Initial findings regarding learner choice in interactive learning and navigation are context-specific, yet the findings warrant further investigation on a larger scale. Technical constraints impacted on the design and implementation of an active learning prototype. Canvas LMS and the university digital ecosystem had few integrated tools that could be used to foster a collaborative and connected learning at the scale required. As such, beyond active student engagement with information and online discussion with existing tools, this research did not trial and expand the repertoire of collaboration designs and tools that encourage peer-to-peer interaction in technology-enhanced learning. This project has highlighted this as a critical area to develop a sustainable connected learning experience at scale.

While the focus of this paper is on learner engagement data, the paucity of student response in the end of semester survey limited analysis of motivational factors. Additional student and tutor qualitative focus group feedback was gathered to triangulate the above data for internal evaluation purposes only and as baseline data for future research. Further qualitative research is needed to understand student behaviour, their motivators and inhibitors, particularly social, collaborative and emotional dimensions as they engage online (Redmond, Heffernan, Abawi, Brown, & Henderson, 2018).

Conclusion

In higher education, redesigning digital spaces on a larger scale to enable more active learning, beyond interaction with content, is an urgent priority. This research paper described an innovative design that emphasised non-linear and interactive learning as a prototype. One of the novel findings of this paper was that while a large proportion of students followed a teacher-designed sequence, others navigated the prototype in a multitude of entirely unexpected ways.

Next steps include investigating how students work through the prototype with qualitative user experience (UX) research to uncover further insights into possible enablers and barriers to iterate the learning design. Future research might also consider how such prototypes provide models to reduce or remove traditional lectures and expand active, problem-based learning, leveraging the affordances of technology.

In this study, students were encouraged to actively engage with business discipline knowledge through learning activities in a self-directed manner with the aim of extending this practice and participating in active learning in the face-to-face environment. In this sense, the prototype design achieved its goals.

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