Understanding Alignment Between Design Approaches and Student Priorities for Online Learning Platforms

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Plagiarism Declaration

I, Xue Jun Jian, hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Abstract

With the increasing number of public institutions turning to online learning, there is a need to understand the process of online learning development and how it aligns with student priorities for online learning platforms. This is exacerbated by the onset of COVID-19, with many institutions hastening to move their courses online during the global lockdowns, making it even more a priority to understand online learning practice.

Various studies have reported on best online learning practices but deviations from student priorities still exist in reality. In practice, courses are predominantly designed from the lecturer's perspective, and student perspectives are only incorporated through feedback from course evaluations. Students are rarely given a role in the design process and are therefore unable to sculpt out their design needs for online courses. One design approach which gives a design role to students is co-design. Co-design takes into account the perspectives of all stakeholders by allowing each stakeholder to equally participate in the design process.

The participation of students in design and the degree of participation they take has rarely been articulated. How does the design approach from the lecturer's perspective, where students take no part in the design process, compare to the co-design approach, where maximum participation can be achieved? How do these design approaches contribute to the deviations from student priorities?

The aim of this study was to understand the alignment between design approaches and student priorities for online learning platforms and how deviations transpire. This research posited that a co-design approach, including the students as designers, might assist in alleviating these deviations. In the first part of the study, the researcher interviewed current students in an online course to understand their priorities for design. Results from the interviews were analysed and shared with students and lecturers, who were invited to prototype designs for a lesson module based on this feedback, first individually, then as a group. Another set of students were then invited to compare and evaluate the implemented prototypes in the final part of the study.

The results demonstrated that a) expressed student learning priorities generally aligned with current knowledge of online learning design, b) a gap between design and reality exists for actual online course practices, c) design deviations from student priorities emerged at the beginning stages of the design process, where individual interpretation of design needs differed, d) design discussions and idea sharing during co-design alleviated these deviations, and e) co-design activities stunted the creativity of the team.

Although co-design managed to bridge part of the gap between online learning platform design and student priorities, there are many factors that limit effective multi-stakeholder co-design. Depending on characteristics of individuals, team dynamics and design environment and conditions, the full benefits of co-design may not always be realized. Future works should explore ways of gaining mainstream adoption of design approaches such as co-design, to bridge the gap between design and reality in the online learning space.

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1 Introduction

Online education is on track to becoming mainstream by 2025, with an increasing number of universities converting their lecture materials into content that can be easily accessed online (Allen & Seaman, 2003; Palvia et al., 2018). However, these online learning designs do not necessarily meet the learning needs of students. The problem is that the learning abilities acquired in the classroom differ to that of the abilities required for online learning (Kuo et al., 2014; Martinez, 2003), yet these differences are not always transferred into the design of online learning courses. This introduces the need to understand the alignment between online learning designs and online learning priorities of students.

There have been many studies around online learning and its ability to satisfy students (Levy, 2007; Palaigeorgiou et al., 2011; Shea et al., 2003a). Why then are there still discrepancies between online learning designs and student needs? In practice, educators often design courses from their own perspective and attempt to account for student priorities and perspectives (Conole, 2013), often referred to as teacher design (Bennett et al., 2018; McKenney & Voogt, 2012; Pepin et al., 2017). Rarely do students take up a design role in a course - they are treated as the users. This forces the student into a passive role, where they don't have the platform to sculpt out what works for them.

On the other hand, co-design treats the user as an expert in his/her domain of experience and allows the user to become a co-designer in the design process (Sanders & Stappers, 2008). This design approach takes into account the perspectives and needs of all stakeholders taking part in the design lifecycle (Conole, 2010; Sanders & Stappers, 2008). The benefits of co-design in online education have been well-stated and implemented in many studies (Chao et al., 2010; Matuk et al., 2016; Yamagata-Lynch et al., 2015). However, in practice, there is little evidence of mainstream adoption. An example is the case of the Master's in Information Technology (MIT) online course at the University of Cape Town (UCT), where traditional teacher design approaches are still practiced. The question then is, do design deviations from student priorities still exist because of the poor adoption of design approaches such as co-design?

With the onset of the COVID-19 pandemic, online education is even more relevant on a global scale, as every country has been affected and more institutions are gearing towards the online space. It is therefore critical to understand these design approaches for online learning and where in the process do deviations from student priorities form.

1.1 Background

1.1.1 What is Online Learning?

Online learning has many terms associated with it; examples include online education, distance education, distance learning, e-learning/elearning, internet-based learning and internet-delivered learning (Aparicio et al., 2016; Moore et al., 2011). In this study, online learning is defined as the use of a set of multimedia and instructional design principles to stimulate effective learning via the internet. In conjunction, this study refers to an online course as any course that is delivered online or in an online learning environment (Allen & Seaman, 2003).

An increasing number of universities have utilized online learning concepts and technology innovations to transform traditional classroom lectures into easily accessed learning materials that can be delivered online, with over 90% of public institutions offering at least one online course (Allen & Seaman, 2003). This is also driven by the demand for globalized education where the benefits of economic and cultural integration can be realized.

Online learning requires a different set of skills than classroom learning, such as self-directed learning, internet self-efficacy and disciplined self-motivation; this poses a problem for most learners who have developed classroom learning abilities in primary and secondary school in which instructors are present to adjust aspects according to what they observe of the students (Kuo et al., 2014; Martinez, 2003). This influences the persistence and engagement of students who have not yet acquired the skills for self-directed learning. In parallel, the development and design of online courses need to take this into consideration. The successful online education design is one which recognizes the student's way of learning and takes into consideration the way a student may want to learn (Martinez, 2003). A possible method of addressing the gaps in online learning, such as the ones mentioned above, is to employ iterative design or co-design.

1.1.2 What is Co-design?

There is a range of vocabulary that is synonymous with co-design. Depending on the literature, co-design has been referred to as codesign, collaborative design, participatory design, cooperative design, cocreation or co-creation (Muller & Druin, 2012; Sanders & Stappers, 2008). Some authors make slight but clear distinctions between these terms while other authors take it as the same term, but the most prominent difference is in the historical context. Early works within the last 50 years coined collaboration and cooperation in design as participatory design, with its origin in the Scandinavian workplace democracy movement and considered strictly in a political context (Muller & Druin, 2012). More recent works use co-design and participatory design interchangeably (Sanders & Stappers, 2008). Regardless of the terminology, the principle behind co-design remain the same: to collect the various perspectives of key stakeholders in the design development process.

In this study, the definition of co-design and participatory design will be taken as one of the same, that is: co-design is the group act of designing an artefact that takes into account the inputs of and actively involve various key stakeholders. An artefact in this sense is an object that is given shape by the process of design, such as an interface, website or software application.

Compared to iterative design, where designs are refined cyclically based on user testing and other evaluation methods, thereby limiting the extent of usability it can attain (Nielsen, 1993), co-design can break these limits through fresh new perspectives and idea introduction.

A variety of approaches to design are explored in this research, ranging from more individual or expert-led approaches to group engagements that better embody co-design principles. From a co-design perspective, this study considers all stakeholders to be experts in their own domain: lecturers are experts in teaching, pedagogy and course design; students are experts in their own context and ways of learning.

Frequently courses are designed by the lecturers alone, which is often described as "teacher design" in educational literature (Bennett et al., 2018; McKenney & Voogt, 2012; Pepin et al., 2017). Lecturers are informed by course evaluations and experiences with students, from which feedback is incorporated into the design of the course the following year. With a co-design approach, students would be involved in the design.

1.1.3 Master's in Information Technology

i. How are modules currently offered?

The Master of Information Technology (MIT) course is a conversion course offered part-time or full-time at the University of Cape Town to students without an information technology (IT) background. Currently, it is an online learning course that consists of coursework and a dissertation, with each coursework module designed by the respective instructor. The course introduces information technology (IT) subjects to students including Python Programming, Human-Computer Interaction, Database Systems, Cyberlaw and Ethics, Computer Networks, and Web Programming. The goals of the course are to equip the students with skills required in the IT sector and provide them with a formal university qualification in IT.

The MIT coursework is delivered online and consists of self-study notes, two assignments and an examination taken in person at the university. It is mainly supported through Vula, the online environment used for courses at UCT. The assignment deadlines and examination dates are provided to students at the outset of the academic year to allow students to organize their schedule and plan ahead.

The course content is typically delivered in PDF files with all chapters available at the beginning of the course. Some of the courses provide content with review questions and some contain lecture videos as supplements. Interactions between students and tutors as well as students and lecturers are generally online via a chat room or collaboration tool. The interaction platform changes from year to year, with the most recent one being the Vula chat room.

ii. What online platform is used?

Vula is the online collaboration and learning management system used by UCT, with Sakai as the underlying platform. Sakai is an educational software platform that is a free community source and designed to support teaching, research and collaboration. These types of systems are also called Learning Management Systems (LMS), Course Management Systems or Virtual Learning Environments.

Vula is used to support all UCT courses and includes administrative, assessment, communication and resource sharing features. A registered student has access to the website's features and can create their own project or research sites on the platform. The primary purpose of Vula is to support classroom learning.

iii. Who are the students in the course?

The students in the course vary but typically are young individuals who use information technology in their job but lacks a formal IT qualification. There are individuals who work full-time and are part-time MIT students while some are full-time MIT students. The work experience of the students may also vary, with some students taking MIT immediately after completing their undergraduate degree. The MIT degree is open to students with the equivalent of a South African Honors degree who have not taken computing or IT subjects in their previous degrees. Class sizes vary for each coursework module but typically consist of 15-20 students.

1.2 Problem Statement

The current MIT course at UCT is delivered online with limited incorporation of theoretical concepts for online course design. The modules in the course are designed by the lecturers and students are not incorporated in the design process. This study explores the phenomena that occurs with a co-design approach of an online lesson interface, how it compares to a design approach from a predominantly lecturer perspective, and the ability of these design approaches to satisfy student needs in the online learning space.

1.3 Aims and Objectives

The aim of this study is to observe and analyse a particular case of online course design in the MIT course and understand some of the ways that design trajectories emerge in relation to the participation of students in the design. The key objective is to identify phenomena that contribute to deviations between design and student needs.

1.4 Research Questions

To explicate these issues, a case study was developed around the design of an online course, working with a lecturer and students that have completed the course.

The research questions this study addresses are:

RQ1 – How do expressed student priorities compare to current knowledge of online learning design and actual online course practices?

To address RQ1, current and past MIT students were interviewed to understand their online learning priorities, and the interviews were analysed with respect to existing theoretical knowledge of online learning design and current online course practices in the instance of the MIT course at UCT.

RQ2 – How do different design approaches affect the outcome of an artefact and user satisfaction in the online learning context?

To answer RQ2, an educator and two students were invited to design a lesson interface for a module of the MIT online course. Students were then invited to offer feedback on these designs.

1.5 Approach

This study was divided into three chronological phases: a) eliciting student requirements; b) design and prototyping of MIT coursework and c) student evaluation. Ethical clearance was provided prior to phase commencement.

The study was kicked off by interviewing 21 current and past MIT students to enquire about the presentation and engagement of online courses in general and the MIT course, as well as the opinions, experiences, and ideas of the participants regarding online learning and course design. Demographic information such as sex, highest degree held, and year of study were gathered.

The next phase made use of design sessions to sketch the low-fidelity prototypes to be used for the evaluation of the MIT Relational Databases module's online offering. This module was chosen as it was representative of the MIT modules that required redesign. The design sessions explored three design approaches:

a) Teacher design
b) Design in consultation
c) Mutually produced design

The sketches from the design sessions were then developed into high-fidelity prototypes on Vula by the researcher.

Finally, students participated in a cognitive walkthrough and semi-structured interview to evaluate the online learning interface designs. Each evaluator was given a Vula site that presented the high-fidelity prototypes, where they were asked to evaluate, rate and rank the designs based on their learning needs, as well as the prototypes' ability to meet online learning requirements.

A detailed description of the method for each phase is discussed in the relevant chapters.

1.6 Limitations of the Study

The approach method of this study does not reflect actual design practices and is not meant to represent design work in reality. Rather, this study can be used to understand the phenomena that can occur as a result of different approaches to design in a particular case. This study was based on the MIT course at UCT and the participants thereof, and the findings may be limited to similar courses in this setting. Furthermore, the sample size was small, and a larger sample size could have given the study more user representation.

1.7 Thesis Structure

This study is divided into seven chapters. Chapter 1 provides the background and context for this study. This is followed by Chapter 2, which presents an overview of the existing literature related to design approaches and online learning. Chapters 3 to 5 analyse and discuss the results of these three phases. Finally, the study is concluded in Chapter 6, where the contributions of this study are summarized and opportunities for future work are identified.

2 Literature Review

2.1 Design for Online Learning

Modern education has changed rapidly within the last decade, where traditional design approaches no longer meet the needs of modern learners (Conole, 2010). Innovative approaches to pedagogy and use of technology have constantly popped up and seem to offer better learning experiences for learners. However, in reality there are many educational offerings that are still based on traditional, outdated design approaches, such as that of implicit, belief-based practices and standardized educational systems (Conole, 2010). It is therefore important to define design themes and concepts for the online learning space.

2.1.1 Online Learning Interface Design

Usability is key for an effective online learning platform (Dringus & Cohen, 2005). Flavián et al. (2006) defined usability in general as the ease of understanding the structure of the interface, simplicity of use, speed of navigation and degree of user control. A method to improve usability is to use heuristics, where evaluators use a small set of principles to inspect an interface to find usability problems (Nielsen, 1994). Usability heuristics were adapted by Dringus & Cohen (2005) and made specific for online courses, in which they defined 13 heuristic categories, namely: visibility, functionality, aesthetics, feedback and help, error prevention, memorability, course management, interactivity, flexibility, consistency, efficiency, reducing redundancy and accessibility.

Heuristics are used to evaluate interface usability; design concepts support effective design of usable interfaces - what is needed is a model of concepts that guide the design of online learning materials (Ally, 2008). Effective online learning design concepts are summarized by Janicki & Liegle (2001) to include ten distinct features, namely instructor as a facilitator, variety of presentation styles, multiple exercises, hands-on problems, learner controls the pace, testing, feedback, clear navigation, help screens and consistent layout.

Swan (2003) on the other hand, divided student-content interaction into six broader concepts, including clear goals and expectations for learners, multiple representations of course content, frequent opportunities for active learning, frequent and constructive feedback, flexibility and choice in satisfying course objectives, and instructor guidance and support. These concepts were derived across various research papers, looking at the intersections between computer-based learning and learning in higher education and grouped into common organizing concepts.

The quality of an online course design is mentioned by Jaggars & Xu (2016), who found that many sources differed widely on what defines the quality of an online learning course. However, they broadly categorized the findings into four general concepts: the extent of which the course interface is well-designed and easy to navigate, the clarity of learning objectives and performance standards, the strength and diversity of interpersonal interaction, and the extent to which technology is effectively used. Expanding on the course interface design and navigation category, Jaggars & Xu (2016) found from various studies that ease of navigation and ease of use was a key quality of an organized and structured course. A study involving a thorough literature review of trends in online courses identified four consistent themes in 17 literature papers: structure and security, content presentation, collaboration and interaction, and feedback (Lister, 2014).

From the literature, it is clear that no single model of concepts is universally applied. The design themes and concepts for the online learning space has generally been defined based on the requirements for the study. In this study, exploring the design of an online learning interface and the online learning effectiveness thereof is one of the key research areas. Extrapolating from these research papers, the concepts by Swan (2003) encompass student-content, student-peer and student-lecturer interactions, and merges this into student-interface interaction, which is primarily the focus of this study. The concepts are broad enough in that it can incorporate concepts from other studies, such as that of Janicki & Liegle (2001), and yet have sufficient detail that the concepts do not overlap. This study therefore makes use of these concepts as a starting point.

2.1.2 Learning Design Techniques and Evidence for Benefit

Educators have to implement different teaching methods and be innovative in their approach for students to be engaged with learning and course content presented (Kiryakova et al., 2013). There have been a number of studies in which online course designs considered strategic, institutional, economic, social and technological aspects but pedagogical considerations were lacking (Guardia et al., 2013). Trends in education have shown a need for new approaches to be implemented for active learning to take place, which is important for student engagement (Kiryakova et al., 2013; Prince, 2004). There have been techniques and learning mechanisms that have been introduced to enhance learning. However, it is important to match the new techniques to suitable cohorts as an aspect of learner engagement is dependent on the learner attributes. Thus, to implement a learning mechanism, an analysis of the participants, context and available tools is required for effective implementation. A strategy for implementation can be as follows (adapted from Kiryakova et al. (2013)):

a. Determine characteristics and demographics of participants
b. Define the learning objectives
c. Create/modify the educational content and activities for the technique
d. Implement the technique

Two techniques in particular have been well-established and suggested to enhance learning, namely gamification and interactive learning tools.

i. Gamification

Gamification can be defined as the integration of game thinking and game elements in a non-gaming context to motivate and engage participants (Kiryakova et al., 2013). It is used to influence learner behavior, commitment and motivation rather than being a mode of content delivery in the educational context. Amongst the distinctive features of games, the main features which make gamification effective include challenges/tasks for users to perform, point systems to quantify their achievements, levels to aspire to, rewards for completion and ranking systems for comparison (Kiryakova et al., 2013). Gamification in online learning platforms can increase student motivation and engagement but it requires a significant number of resources to develop and implement an effective gamified online learning model (Domínguez et al., 2013; Urh et al., 2015).

ii. Interactive Learning Tools

Interactive learning is a pedagogical approach where learners actively participate and engage with learning through three interactions, i.e. interaction with content, interaction with peers and interaction with instructors (Swan, 2004). Interaction with content refers to the student's interaction with the course materials and design, interaction with peers have to do with learning via social interactions and discussions with classmates, and interaction with instructors describe the relationship between online teaching practices and student learning (Swan, 2004). The two components that form interactive learning in course design and delivery are:

- social networking, where virtual social networks are used to exchange information
- urban computing, where information and data is acquired through diverse sources such as wireless networks, smart phones and location-based media in urban spaces.

Interactive learning tools in the context of online learning are platforms or technologies that facilitate learning through the virtual environment. These tools can be in:

- synchronous form, such as videoconferencing and web-conferencing platforms that can assist with virtual discussions and lectures or
- asynchronous form, such as online discussion forums, blogs, social media websites and software that incorporates various interactive elements.

The learning effectiveness is dependent on the quantity and quality of interactions through interactive learning tools, which can include online postings in forums, student-instructor interactions, vicarious peer interactions and individualized feedback (Swan, 2004). Online interactions may support divergent thinking, complex understanding and experimentation better while detracting from scientific and convergent thinking (Swan, 2004).

2.1.3 How Is Effectiveness Measured in the Online Learning Space?

There are many measurements used to quantify effectiveness in the online learning space, including dropout and retention rates, participation rates, cost/benefit ratios, student performance, online interaction rates and student satisfaction (Benigno & Trentin, 2000; Levy, 2007; Selim, 2007). The evaluation of online education is more complex than traditional courses as there are more elements to consider due to the flexibility and wider range of implementation in online courses (Benigno & Trentin, 2000). The possible macro (technology, content and structure, cost/benefits ratio) and micro (participation, goal achievement, individual learning) elements that can be identified and evaluated has a strong impact on the development of innovative education systems (Benigno & Trentin, 2000).

A considerable number of studies use questionnaires and surveys as a method to qualify effectiveness (Benigno & Trentin, 2000; Levy, 2007; McGorry, 2003; Selim, 2007) and implement the Likert-type scale (McGorry, 2003; Selim, 2007). Various measure factors are used such as those shown in Table 2-1.

Table 2-1 Measure factors used to qualify effectiveness in online learning

Measure Factor	**Author**
Instructor characteristics (teaching style and attitude)	(Selim, 2007)
Student characteristics (learning style, experience and attitude)	(Selim, 2007) (McGorry, 2003) (Benigno & Trentin, 2000)
Technology access, design and usage	(Selim, 2007) (McGorry, 2003)
Support structure (by university, tutors, technology or experts)	(Selim, 2007) (McGorry, 2003)
Dropout and retention rates	(Levy, 2007)
Student participation or interaction rates	(Benigno & Trentin, 2000) (McGorry, 2003)
Cost/benefit ratios	(Benigno & Trentin, 2000)
Student performance	(Benigno & Trentin, 2000)
Student satisfaction	(Shea et al., 2003a) (McGorry, 2003) (Levy, 2007)

i. The Significance of Student Satisfaction in the Online Learning Space

Several studies have cited student satisfaction as a major factor in measuring the effectiveness of online learning courses, with issues such as instructional design and course organization being key influencing factors (Levy, 2007; Shea et al., 2003a).

Student satisfaction is associated with student performance and the quality of an online program, with learner-content interaction suggested to be most important in online learning (Kuo et al., 2014). A study by Palaigeorgiou et al. (2011) also identified that content and presentation of online learning resources as the most important factor for an online learning environment, with it making up the majority of student needs.

The importance of how positively students view their learning experiences has been a direct indicator of student performance expectancy and a critical indicator of academic achievement (Bolliger & Martindale, 2004; Kuo et al., 2014; Liao & Hsieh, 2011). Student satisfaction as an online learning effectiveness indicator should be studied to increase retention and future student recruitments (Kuo et al., 2014).

The results of these studies are no different to the research performed in the college or university setting, in which satisfaction has been linked to achievement motivation, grade point average (GPA), student retention, student attrition and performance (Ralston-Berg & Nath, 2009). However, a study by Choe et al. (2019) found no statistical significance in the relationship between student satisfaction and learning outcomes. Rather, the authors found that student satisfaction is related to student engagement and is important because universities are essentially service providers that need to satisfy their customers.

According to studies, student satisfaction has been consistently linked to retention rates, and has been a major predictor for student success (Herbert, 2006; Schreiner, 2009). A study by Herbert (2006) showed that students who were more satisfied with all aspects of an online course were more likely to graduate. Schreiner (2009) found that the predictive ability of satisfaction indicators on retention rates almost doubled that of factors such as demographic characteristics and institutional features.

Owing to these findings, student satisfaction was used to measure the effectiveness of online learning designs in this study.

2.2 Co-design and Online Learning

The role of co-design and user participation in online learning has been explored to varying degrees. Research scientists in education have established the importance of collaboration with teachers in designing course curriculums and instructional strategies, specifically in educational innovations and enhanced learning technologies (Matuk et al., 2016). Educators and researchers reaped benefits in the co-design process in that teachers learn about their students through reflection and researchers gained a deeper understanding of the role of technology in teaching (Matuk et al., 2016).

Research involving students in co-design of course curriculums and artefacts have been explored to a lesser extent. While there is a plethora of literature on co-design and online learning as standalone topics, a search in Google Scholar using the combined terms of “co-design” and “online learning” yield limited results that merge the two concepts together. Research on co-design in face-to-face teaching is also limited; studies found in this domain include developing learning outcomes (Ebel et al., 2020), curriculum planning (Kelly et al., 2019) and shaping inquiry-based learning (Rakrouki et al., 2017).

Of the available literature, the methods and tools used by the researchers and the degree of stakeholder participation in the co-design process is varying. There is little research in the specific co-design approaches used and its impact on product and user satisfaction (Olivier et al., 2012). While stakeholder participation is viewed as beneficial in many contexts, there is limited literature that actually compares co-design to more individual or expert-led design approaches in online learning. A study by Hoogveld et al. (2003) compared team design to individual design by a group of educators with instructional design experience and found it to be more effective, although it was only evident for low individual achievers but not high individual achievers (Hoogveld et al., 2003; Rienties & Toetenel, 2016). While team design is a collaborative effort, it does not fit the definition of co-design in that it does not involve the key stakeholder, i.e. the student. In a broader sense, co-design refers to the collaborative effort of “designers and people not trained in design working together” (Sanders & Stappers, 2008).This sets the scene for filling the gap in research on understanding the alignment between design approaches and student priorities for online learning platforms.

2.2.1 Defining Student Participation in Co-design of Online Learning

From the literature reviewed, the definition of participation in co-design of online learning varies from using student feedback (Swan et al., 2014; Zaphiris & Zacharia, 2003) to having students perform design tasks (Palaigeorgiou et al., 2011; Warburton & Mor, 2015; Yamagata-Lynch et al., 2015).

In this study, participation is defined as actively engaging in design activities and performing design tasks where interactivity between stakeholders take place, in accordance with the definition of co-design in this study.

2.2.2 Co-design Approaches

A few papers have incorporated students into the co-design process whereby students participate in design activities. Participation in co-design has been suggested to empower students and instructors alike by enabling diverse experiences in teaching and learning through course design and exploring activities (Yamagata-Lynch et al., 2015). The following table includes some of the co-design studies in online learning done in the past decade, extracted from the Google Scholar database. These papers were chosen based on three criteria:

1) The definition of co-design fits the definition in this research
2) The paper was published within the last decade, i.e. between 2010 – 2020
3) The research done is specific to online learning

Table 2-2 A summary of co-design studies within the last decade in the online learning space

Author	Title	Methodology	Participants
(Palaigeorgiou et al., 2011)	What if undergraduates designed their own web learning environment? Exploring students' web 2.0 mentality through participatory design	Conducted 25 design sessions (~2 h and 30 min each) with 4-6 participants and 2 coordinators in each session. Design sessions consisted of 3 phases: i] introductory (introduce design problem and create design alter ego); ii] needs elicitation (visual scenarios and design ideal scenarios using web learning platform); and iii] evaluation (assess extracted needs)	117 Informatics undergraduate students, 2 experienced coordinators who had conducted more than 50 similar design sessions in the past
(Warburton & Mor, 2015)	A set of patterns for the structured design of MOOCs	20 design patterns were developed from 3 workshop sessions. 1st workshop: 25-30 participants share design narratives and develop proto-design patterns; 2nd workshop: 20-25 participants review, refactor and reiterate design patterns and testing design patterns against novel design scenarios; 3rd workshop: 8 participants finalize chosen design patterns for release	63 practitioners and experts
(Yamagata-Lynch et al., 2015)	Design lessons about participatory self-directed online learning in a graduate-level instructional technology course	Pairs of students designed course activities in collaboration with the instructor after 3 weeks of instructor-facilitated activities asynchronous and synchronous sessions	20 Instructional Technology Masters' students, 1 instructor
(Barbera et al., 2020)	A co-design process microanalysis: stages and facilitators of an inquiry-based and	7 participatory workshops to contextualize, problematize & define, document & ideate, conceptualize & prototype a Sustainable Development online course. 3 versions of the product	7 teachers, 3 researchers, 2 students from different disciplinary areas

Author	Title	Methodology	Participants
	technology-enhanced learning scenario	were designed: 1) a teacher's initial proposed learning scenario; 2) learning scenario co-designed between a teacher and 1 or 2 researchers; 3) learning scenario co-designed with a teacher, 1 or 2 researchers and input from 2 students	
(Chao et al., 2010)	Using collaborative course development to achieve online course quality standards	Four courses in different undergraduate and graduate-level programs requiring varying degrees of revision were designed using quality standards, with each co-design team consisting of a faculty member and instructional designer	4 faculty members and 4 instructional designers

Depending on the study, co-design activities have included instructors, students, designers and researchers in the online learning domain (Palaigeorgiou et al., 2011; Warburton & Mor, 2015; Yamagata-Lynch et al., 2015). The number of student participants have varied from a pair of students (Yamagata-Lynch et al., 2015), a group of six students (Palaigeorgiou et al., 2011) to a cohort of more than twenty students (Warburton & Mor, 2015).

The approach to co-design has largely been in the form of workshops and iterative sessions where the stakeholders are actively engaged in design. While artefacts such as design patterns, learning activities and category of student needs have been developed in the co-design and online learning domain, there is a lack of studies that develop an online learning interface as the actual design product for evaluation.

Incorporating students in active co-design has shown benefits in understanding student requirements and developing course design patterns that can be implemented in online learning courses (Palaigeorgiou et al., 2011; Warburton & Mor, 2015). The degree of participation that the stakeholders can take in the co-design process should be considered to maximize the benefits of a collaborative design (Yamagata-Lynch et al., 2015). Co-design, where all stakeholders actively participate in design activities, maximizes the degree of participation.

The antithesis to co-design in the educational context would then be teacher design, where only the educator takes part in design activities. Teacher design work is often directed by the teachers' convictions, goals and cognitive approach to design thinking (Bennett et al., 2018; Pepin et al., 2017). This cognitive process is often defined by divergent and convergent thinking, where various ideas emerge cognitively in an unorganized manner through divergent thinking, then organized and developed into a single output through convergent thinking (Guilford, 1956). In teacher design, educators' only have their own domain of knowledge and expertise as a basis for their output. Compare this to co-design, where the student's domain of expertise can be accessed in addition to the lecturer's, and divergent and convergent thinking can happen as a group.

The various degrees of stakeholder participation in design processes are rarely considered (Vines et al., 2013). The different design approaches (from teacher design, where no degree of student participation takes place, to co-design, where maximum participation can be achieved) and its alignment to student needs for online learning platforms have not often been articulated. It is important to understand this alignment so that phenomena that contribute to deviations between design and student needs can be identified.

2.3 Design-Reality Gap in Online Learning

Co-design has been considered a useful mechanism to bridge the design-reality gap (David et al., 2013; Kyakulumbye et al., 2019). The design-reality gap is the gap that exists between current, local user realities and the design of the information system (IS) (Heeks, 2002). This theory was first devised for developing nations, where failures of IS projects were attributed to the size of the design-reality gap, i.e. the larger the gap, the greater the risk of failure (Bass & Heeks, 2011).

A study by Bass & Heeks (2011) sought to understand the design-reality gap in the higher education space, and identified eight dimensions to measure, namely objectives and values, processes, technology, information, management systems and structures, investment resources, staffing and skills, and milieu, summarized as the OPTIMISM acronym. This paper focused on assessing this design-reality gap rather than understanding the phenomena causing this gap. In fact, two studies that have applied the design-reality gap in the higher education context have used the model as an assessment and evaluation tool, and both have concluded that the design-reality gap still exists even though progress has been made (Bass & Heeks, 2011; Dasuki et al., 2015).

While Heeks (2002) focused on the types and size of the gaps, Masiero (2016) attempts to identify the root causes of the design-reality gap by developing the ITFOCHI taxonomy, shown in Table 2-3.

Table 2-3 The ITFOCHI taxonomy for the causes of the design-reality gap

No.	Class	Explanation
1	Informational	Designers not fully informed of tools available, problem to be solved and/or on its context
2	Technological	Technology needed for optimal design not available
3	Financial	Financial constraints to implement certain designs
4	Organizational	Limited by organizational/political principles
5	Cultural	Local culture effects on system design
6	Historical	Historically induced factors may affect design
7	Institutional	Norms and routines in existing institutions may play a role in influencing the outcome

Masiero (2016) emphasizes that the causes of the design-reality gap are due to dynamic processes between the taxonomy factors rather than of a single, standalone factor. The ITFOCHI taxonomy model provides a systematic way to analyze the phenomena at the root of failure (Masiero, 2016).

The design-reality gap could explain why deviations from student priorities for online courses still exist. However, a search in Google Scholar indicates that few studies have analyzed the design-reality gap in the higher education context, and even less so for online learning.

3 Focus Areas for Online Learning Design

This chapter summarizes the responses to the requirements elicitation interviews and addresses the question: *how do expressed student priorities compare to current knowledge of online learning design and actual online course practices?*

A discussion of how the student responses compare to that of current online learning design knowledge (presented in the literature review, see section 2.1) and actual practices of the MIT online course is presented in this chapter.

3.1 Methodology for Online Learning Design Focus Areas

Interviews were used to elicit online learning requirements from the students, as it allows the researcher to observe the feelings and thoughts of the students.

3.1.1 Interviews

The main selection criteria for the interviews are students who have enrolled in the MIT coursework in recent years (2017 to 2020) and have access to the internet. This includes any individuals who are currently enrolled or have enrolled in the MIT course. The interviews were done on a voluntary basis with no incentive to ensure the feedback was genuine and not incentivised. Due to the limitation of resources, any individual who met the selection criteria were considered qualified to take part in the interviews.

The interviews were done over a WhatsApp audio call. During the call, the interviewer recorded the responses on a template. The interview questions (Appendix D) were pre-determined and structured based on the online learning concepts from Swan (2003) (see section 2.1.1), namely a) clear goals and expectations for learners, b) multiple representations of course content, c) frequent opportunities for active learning, d) frequent and constructive feedback, e) flexibility and choice in satisfying course objectives, and f) instructor guidance and support. If there were responses that were not clear or the interviewee did not understand the question, the question was rephrased, or examples were given to elicit responses. Each interview took between 20 – 40 minutes.

3.1.2 Data Analysis

The interviews were analyzed using coding. Coding organizes and makes sense of textual data; it subdivides the data and assigns categories to it (Basit, 2003). The coding takes into account how these categories fit into the wider analytic context to ensure it is useful for the analysis (Dey, 2003).

Coding of the interviews were done in two phases. First, during the interviews, points that were considered important were noted down. The raw data was imported into the NVivo 12 package and coded based on recurrent themes that occurred in the responses.

The second coding phase consisted of creating subcategories within these themes, based on the sentiments and ideas of the content. Outliers or interesting points were marked and noted down. The number of responses for each category were recorded. Coding was done until it reached saturation, i.e., no further coding could be done.

Table 3-1 Themes and subcategories used in the coding phase

Theme	Subcategories
Navigation	Easy to follow, ease of access, everything integrated, searchable
States of Representation	Video, PowerPoint, text, audio
Active Learning	Types of assessment, show progress, time estimates
Feedback	Individualized, timeframes, feedback format
Interactive Communication	Live interaction, chatrooms, email, hybrid, interaction tools

3.1.3 Demographics

Of the 53 students in the MIT program that the interview invite was sent out to, 21 students (39.6%) volunteered to take part in the interview. The interview respondents consisted of 8 female students (38%) and 13 male students (62%). These included 8 (38%) who were enrolled in their first year, 4 (19%) in their second year, 7 (33%) in their third year and 1 (5%) in their fourth year. 18 of the 21 (86%) interview respondents worked more than 20 hours a week, in addition to studying. The highest degree that the majority of the students held was a bachelors/honors degree (14 students, 67%), followed by a master's degree (6 students, 29%) and a postgraduate diploma (1 student, 5%).

The bulk of the students (20 students, 95.2%) used a laptop for their studies. 67% of respondents used their laptop to access course materials, which included activities like reading course content, watching YouTube and other course related videos, downloading textbooks and PDFs and working on assignments.

There were 15 students (71%) who mentioned using their mobile phone for course communication. The activities included checking their marks, looking out for instructions, accessing notifications, messaging, viewing announcements and reading emails. There were 10 respondents (48%) who used their mobile phones to access course materials.

Out of the respondents, only 3 students (14%) used a desktop for their studies, to perform the following tasks: 1) accessing course materials, 2) downloading and working on assignments, and 3) checking and sending communication.

Not many respondents owned a tablet, with only 3 students (14%) who used their tablet to access course content and only one respondent (5%) used their tablet for communication.

3.2 Findings for Online Learning Design Focus Areas

3.2.1 Online Learning Interface Design

i. Navigation

Navigation encompasses the ideas of course organization on an interface, such as where to start, finding course components, where to go and what to do next (Grandzol & Grandzol, 2006; Jaggars & Xu, 2016; Quality Matters, 2020).

The majority of respondents ranked "ease of navigation" and "easy to follow" as one of the most important characteristic of an easy-to-use online learning platform, with

95.2% mentioning it in the top three characteristics. Students specifically mentioned that the “navigation to materials, instructions and requirements need to be clear”. For example, a respondent mentioned that the “process to get to the starting point of a course, from finding out about the course to registration” must be clear and the information “should not be hidden”. One suggestion was to “learn from e-commerce” and the way e-commerce structures its “process of accessing journey”.

Not only should the platform navigation be clear, but respondents would also like the course material to be easily searchable, i.e. notes and discussion forums are searchable, course material is indexed, or a search functionality is implemented. Other aspects of navigation that should be considered in the platform design include minimising login authentication and compartmentalising information and modules.

About 19% of respondents would like everything on one online learning platform so that there is no need to use external software, leave one platform and move to another or register for multiple platforms.

ii. States of Representation

States of representation describes the delivery mode of the learning content, such as video, audio, text, etc. Interviewees responded very strongly regarding content delivery. There were 81% responses that included video as the preferred method of course content delivery. In the case of MIT, some responses specifically mentioned the need for a “variety of ways to disseminate information, like videos”. The bulk of these responses (16 students, 76%) said it was important to use a combination of presentation styles for online courses, with the most popular response being in the form of video supplemented with either text or PowerPoint. Some respondents mentioned that video can highlight “specific or important” points and place emphasis or elaborate on important content/points, while other respondents said videos are good for “demonstration” purposes and would want “high level content as visual as possible”.

For those who mentioned PowerPoint (12 respondents, 57%), five of them commented that PowerPoint is a useful tool as it can provide a summary of the core points of a topic. It also allows the student to take notes while learning the content through reading or watching videos.

There were 57% of respondents that mentioned delivering content in text, as text covers all the content that students are required to know.

For those who mentioned audio (19%), it was mostly as a supplementary to other presentation styles and none of the respondents felt particularly strongly to include it. It was considered a “nice to have” to listen to while “driving or doing chores”.

iii. Active Learning

Active learning refers to the activities that promote student engagement and actively engages students with the learning content, as opposed to passively receiving information (Prince, 2004). An impetus to active learning is gamification, which uses a reward-driven game design element to motivate engagement in tasks (O’Donovan et al., 2013).

With the exception of one interviewee, all other respondents (95.2%) wanted to have an interactive interface that provided active learning, which included knowledge checkpoints, quizzes or self-assessments (with answers) within the online learning platform. This would engage the students, help them benchmark their acquired knowledge and keep track of where they are in the course as well as "cement knowledge".

Gamification was not specifically mentioned in any of the responses, but phrases used by the respondents such as "progress", "level", "break it down", "motivation", "clear milestones" and "bite-sized pieces" did allude to using gamification. For example, more than one respondent mentioned that assignments and materials should "get more difficult as you move with it" and the platform should allow "smaller, more frequent assignments". A key word that one student mentioned was "incentivise". In their words, "unless someone is forcing me to do it, I won't do it, which is why marks would incentivise people".

Some students suggested using a "tracker" or "tick off" of sorts to "show progress" and "benchmark where you are" in the modules. One student mentioned that it would also "negatively impact motivation" if students were "stuck on a section for too long". A suggestion was to use elements like "time estimates" to keep track of this.

This reiterates the fact that students want to see progress in their learning and this progress gives them motivation to continue. It is good to "see where you are and how far you are" and "which phase you are in" so that the student "can work towards a goal". Elements that can show progress were consistently mentioned in the top five characteristics to have in an online learning platform.

iv. Feedback

Many studies have explored feedback in online courses and it refers to the reaction of the system or teaching staff to the students' performance of a task, assignment or assessment, as well as reaction to questions by the students (Janicki & Liegle, 2001; Lister, 2014; Palaigeorgiou et al., 2011; Swan, 2003).

More than half of the interviewees mentioned they would like detailed individual feedback on assignments in an online learning course. The responses regarding the feedback format can be separated into overall assignment feedback and section specific feedback. Sentiments on section specific feedback were quite unified: to write inline comments on the assignment. To implement this, suggestions included using the Microsoft Word built-in comment function or annotated notes on the submission. For overall assignment feedback, a few respondents mentioned that rubrics provided before and after an assignment, with mark allocation breakdown and comments are very helpful. It allows the student to see how they perform compared to expectations and also helps them realize which areas to focus on.

Timeframes were also an important factor in terms of feedback and response by the lecturers and teaching assistants. A suggestion was to enable the platform to "give a timeframe of when tutors and lecturers should reply" so that student expectations can be managed.

v. Interactive Communication

Interactive communication refers to the communication between teaching staff, peers and students and the interactive tools that enable this communication.

There was an overwhelming need for better interactive communication on the platforms, with suggestions including live video interaction (47.6%) chatroom or group chat (42.9%), email (9.5%), or hybrid model that is a combination of platforms (9.5%). In general, students seemed to want "human interaction even though it is a self-study course" and felt that "more collaboration would be good".

In terms of structure, the platform should allow scheduled or dedicated sessions of student lecturer interaction to be created. Suggestions included weekly catchup sessions, assignment Q&A sessions after release and exam preparation sessions. The platform must enable a timeframe to be set for lecturers or teaching assistants to respond in, as this would manage student expectations and also provide accountability.

One concern that came up more than once was the level of interactivity that the platform provided; they didn't like using a specific platform because very few stakeholders were making use of it. One respondent mentioned that "the type of platform does not matter, if it helps lecturers or teaching assistants provide quick and instant feedback then that would be the ideal platform". This should be taken into consideration when designing the platform or selecting the interactive tool.

a. Synchronous Tools

There were 11 responses (52.4%) that believed synchronous tools were necessary for interaction within a course, citing that video tools "encourages more engagement" and that there is "no rapport" in asynchronous chat setups. Most suggestions were around videoconferencing and video calling tools such as Zoom or Microsoft Teams for answering questions, discussion after release of materials or live stream classes. However, there was a concern that live streaming of classes would encounter problems like "bad connection" and result in the student "missing things" in the live stream.

b. Asynchronous Tools

There were many mentions of using asynchronous tools, not only for interaction with peers and instructors but also for interaction with content. It is clear that asynchronous tools are a necessity in the eyes of a student. For interaction with peers and instructors, the most common mention was Slack. A few respondents mentioned WhatsApp but opinions differed on its informal nature, with a respondent who would like to "create an informal environment that replicates a chat system" and another respondent who preferred to have a chat forum similar to it but "not as informal as WhatsApp".

c. Tool Suggestions

Tools like Slack, Microsoft Teams and Zoom came up often as an example of the type of interactive platform that the respondents would like. The functions that the respondents found useful on these platforms include sharing screens, adjustable microphone and video, push notifications, organize per subject or course, tag people, add attachments, see who has joined, type chat, videos, conferences and keep track of all the people who "raised their hands".

3.2.2 Other Themes

Other themes that came up in the interviews include: keep data usage in mind, use efficient file formats, fast loading speed, understand the difference between remote students and on-campus students and design for these audiences, have a progress tracker to show where are the student's strength and weaknesses in the course, and provide testing on platforms.

3.2.3 Effect of COVID-19

As these interviews were conducted during the COVID-19 lockdown, students were asked if COVID-19 affected their studies. The responses were almost split in half: 47.6%

of students indicated COVID-19 affected their learning and 52.4% said COVID-19 had no effect on their studies. For those whose studies were not impacted by COVID-19, a large number of them indicated that personally they were not affected by COVID-19 but UCT's response to COVID-19 and pushing back deadlines thereof was the real effect.

For those who were affected by COVID-19, the two major reasons were:

- Colleagues expected them to be available 24/7 which resulted in more office work
- Concentration span is limited since activities are limited to their homes

Other reasons that were mentioned included day structure and priorities changed due family and household responsibilities, lack of resources such as internet and a decent working environment at home, the ongoing COVID-19 pandemic is a distraction in itself and lacking interaction with peers.

Two respondents felt the COVID-19 lockdown had a positive impact on their studies in that they had more time to learn.

3.3 Discussion for Online Learning Design Focus Areas

3.3.1 Alignment Between Student Needs, Literature and Practices: The Case of MIT

What do the findings tell us about the student requirements for an online course? The analysis below examines the alignment of expressed student needs of an online course, current online learning knowledge and actual online courses in practice in the context of MIT.

Currently, the MIT course materials are posted on Vula but with limited use of the platform's features. For reference, the available Vula features are presented in Table 3-2, which will be referred to throughout this discussion.

Table 3-2 Vula features and description of these features

Feature	Description
Overview	Displays the description of the course, calendar, recent announcements and messages
Announcements	For lecturers/teaching assistants to post announcements in text form
Calendar	A calendar by month for students to view
Course outline	A description of the purpose of the course
Resources	Acts as a folder to store course materials
Podcasts	For posting/listening to podcasts
Wiki	A page to explain terms or concepts
Polls	To create polls which participants can vote on
Forums	To post discussions of any topic
Q&A	To post questions and answers
Blogs	For students to post content as a blog post
Messages	For participants to send and receive messages
Email archive	An archive that the participant can store their emails on
Chat room	A chat room for the specific course that all the participants have access to
Drop Box	To link to Drop Box for storage or file transfer purposes

Feature	Description
Assignments	Where assignments are posted or uploaded
Tests & quizzes	For participants to post tests or quizzes which can then be answered
Gradebook	Where marks for assignments and tests are posted
PostEm	To post things
Section info	To provide information on a section
Participants	A list of individuals who are members of a Vula site and their role in the course
Search	To search within the site
Course evaluation	For evaluation of the course
External tool	For embedding external tools such as Zoom, etc.
Lessons	A page where content can be added in many various forms like PDFs, embedded videos, links, etc.
Sign-up	To sign up for activities created by participants such as dance classes
Site stats	To provide statistics of the site such as number of page views, etc.
Help	For guidance/help with Vula sites in the form of questions and answers

i. Clear Navigation and Guidance

While there are one or two modules that make use of the “lessons” feature, the majority of the modules do not. Instead, the course materials are lumped into the resources folder where students download the materials to learn. This is not appealing in terms of navigation and does not meet student needs.

In general, the findings indicate that students desired online learning platforms that have a clear and simple navigation structure which guides the learning process (see section 3.2.1 i). In addition, they wanted a platform that requires minimal time to understand, has few authentication steps and is easily searchable. This gives support to research studies that indicate “intuitive navigation” is one of the key criteria when creating a good online interface (Jaggars & Xu, 2016). It also reiterates the review done by Grandzol & Grandzol (2006), where best practices for online learning include navigational instruction that tells students where to go and what to do next.

The navigational aspects should therefore guide the entire learning process. Aspects such as that of searchable content, minimal authentication and clicks, and clear navigation path to learning material should all be considered when designing an online learning platform.

ii. Multiple Representations of Material

The current MIT modules are predominantly delivered via text, in the form of PDF documents. For instance, for one of the courses that uses the Vula lessons feature, only PDFs are posted per chapter. Features like embedding videos into the lesson and linking to the next chapter are available but not used (see Vula features in Table 3-2). While students may be referred to some video lectures from on-campus courses, most students have to find videos on sites like YouTube if they want course delivery in video form.

Even though our sample size is small, it can be concluded that students perceive video as the best mode of content delivery (see section 3.2.1 ii). This may be due to the fact that the continuous advancement of technology and its use has changed the way individuals consume knowledge. However, students still find that text is important and cannot be done without, whether in long text or summary form. The qualitative responses imply that students prefer to grasp a concept visually via video but still need text as an anchor and to ensure further understanding. This supports Spiro & Jehng (2012) research that students presented with multiple representations of complex material tend to have better understanding than students who consumed knowledge through a traditional linear format. The lecturers/course designers should therefore take this into consideration when developing the course modules and the platform should easily enable this.

iii. Progressive and Active Learning

The current assignment structure in the MIT course consists of two assignments per module, with two weeks for completion of each assignment. Additional assessments such as review questions are available for some of the modules, but these are usually incorporated into the chapter PDFs. Vula has the option to add tests and quizzes (see Table 3-2) but these are not frequently used by the lecturers.

To enhance learning within the course, nearly all of the students voted to have an interactive interface to enable active learning, and more than a third of the students suggested adding some form of optional assessments with answers (see section 3.2.1 iii). This may be dependent on the type of learner and the way they process information. Moallem (2007) suggests that reflective learners who process information by thinking things through and working alone should be provided with self-assessment quizzes as an instructional strategy. The findings strongly indicate a need for gamification (see section 3.2.1 iii) as extrinsic motivation for the students.

Overall, the findings are in line with literature in that active learning methodologies should be adopted and modules should have frequent assessments to challenge students (Grandzol & Grandzol, 2006; Swan, 2003). Course designers should take this into consideration when designing or selecting the online learning platform.

iv. Individualized and Timeous Feedback

Feedback provided by the lecturers and teaching assistants in most of the MIT modules are individualized, which meets the priorities of students. An overwhelming number of students requested inline commentary on assignments and breakdown of mark allocation with rubrics (see section 3.2.1 iv). In addition, timeous feedback was also a priority for the students.

This is in agreement with most literature papers, where feedback that is constructive, prompt, specific and actionable is considered essential for online learning (Jaggars & Xu, 2016; Swan, 2003).

While Vula may not have a specific feature that allows inline commentary, most assignments are currently submitted as Word documents or PDFs which do allow inline commentary. Vula also does not have a timeframes feature. Designers of an online learning platform should consider including these features.

v. Foster Interactions

Currently the MIT course is rather isolating for a student; there are no group assignments and interactions are predominantly with the lecturer or teaching assistant. Even though students are encouraged to interact with each other and the course has an introductory session, interaction still seems to be lacking. This gap may be the result of a missing element: rapport. Rather than force interactions, perhaps what should be considered is how to foster interactions within online courses and build rapport amongst peers and teachers alike.

Interactions within an online learning course were emphasized heavily (see section 3.2.1 v). This includes the interactions with peers and instructors. In fact, quite a few students thought that collaborating with their peers is rather valuable. This contrasts to the work of Jaggars & Xu (2016) where they found that many students looked at peer collaboration as a mandatory course requirement rather than being helpful for their learning. This may support the theory proposed by Anderson (2003) that meaningful learning can occur if one of the three forms of interaction (student-lecturer, student-student and student-content) are at a satisfactory level.

Overall, students desired frequent communication with teaching staff and advocated strongly for active involvement from both ends. These results are supported by Swan et al. (2000) where they found the impact on student perceived learning was significantly impacted by their interaction with their instructors and peers. Shea et al. (2003b) found that students who interacted less with their instructors perceived their learning as less than those with higher levels of interaction.

In addition to perceived learning, the quality of interactions between student and lecturer was found to be the only factor that significantly influenced a student's grade (Jaggars & Xu, 2016). While this is not part of the scope of this research, this notion gives further support to the importance of interactions as voiced by the respondents.

Making use of interactive learning tools in the course may help foster interactions and build rapport. From the demographics (see section 3.1.3), the majority of students used their mobile for course communication. This implies that course designers should consider implementing synchronous tools available via mobile for the courses. To foster interactions, active participation of teaching staff and students would still be required.

vi. Consistency and Manage Expectations

While not mentioned in particular, consistency is a theme that can be drawn from the findings. The consistency of expectations, timeframes and online learning structure were all alluded to (see section 3.2.1). This echoes the idea that a student's perceived learning is affected by the clarity and consistency of goals and expectations in courses (Swan, 2003). Expectations regarding lecturer feedback could be set by giving timeframes, so students know when to stay put and when to escalate. This can be a consideration for the design of an LMS, where expectations, deadlines and timeframes are incorporated. The consistency of the online learning structure can be set by designing the learning platform to allow content delivery through the same logic and tools.

3.3.2 Design-Reality Gap

From the results of this phase, we can see that there is a gap in the way the course was designed and the reality to which it fits, called the design-reality gap (Heeks, 2002). While the MIT modules are supposed to be designed for online learning, the reality is that there is still a lot of improvements to be made to remotely satisfy the online learning needs of the students.

There seems to be a failure in terms of system utilization in the case of Vula, more specifically referred to as interaction failure, where the system is developed and completed but is not being fully utilized by its intended users (Lyytinen & Hirschheim, 1987). Comparing the Vula platform features and the online learning platform needs of the students, Vula appears to be sufficient to meet these needs. However, the features are not being fully utilized by the designers to transform the MIT modules into an online learning space that meet student needs.

The causes of this design-reality gap may not be due to one factor, but multiple factors interacting dynamically (Masiero, 2016). Looking at the taxonomy of causes of the design-reality gap by Masiero (2016) in the literature review (see section 2.3), the causes that are particularly dominant in the case of MIT may include informational, technological and institutional.

In the case of informational causes, designers or lecturers may not be fully informed of the learning needs of students or of the tools available to them to create a satisfactory online module. At the same time, there may be a lack of tools and skills needed for optimal design made available to the designers, resulting in technological causes. Finally, this design-reality gap may also be caused by institutional reasons, such as the reluctance of staff to adopt new practices and computerize processes.

4 Design Sessions and Prototyping

In this chapter, three approaches to design were explored (see Figure 4-1):

1) Teacher design – where the teacher has evaluative feedback and designs the interface layout themselves
2) Design in consultation – where ideas are discussed by the co-designers but the layout design is developed by the individuals
3) Mutually produced design – where both teachers and students actively participate in designing the interface layout

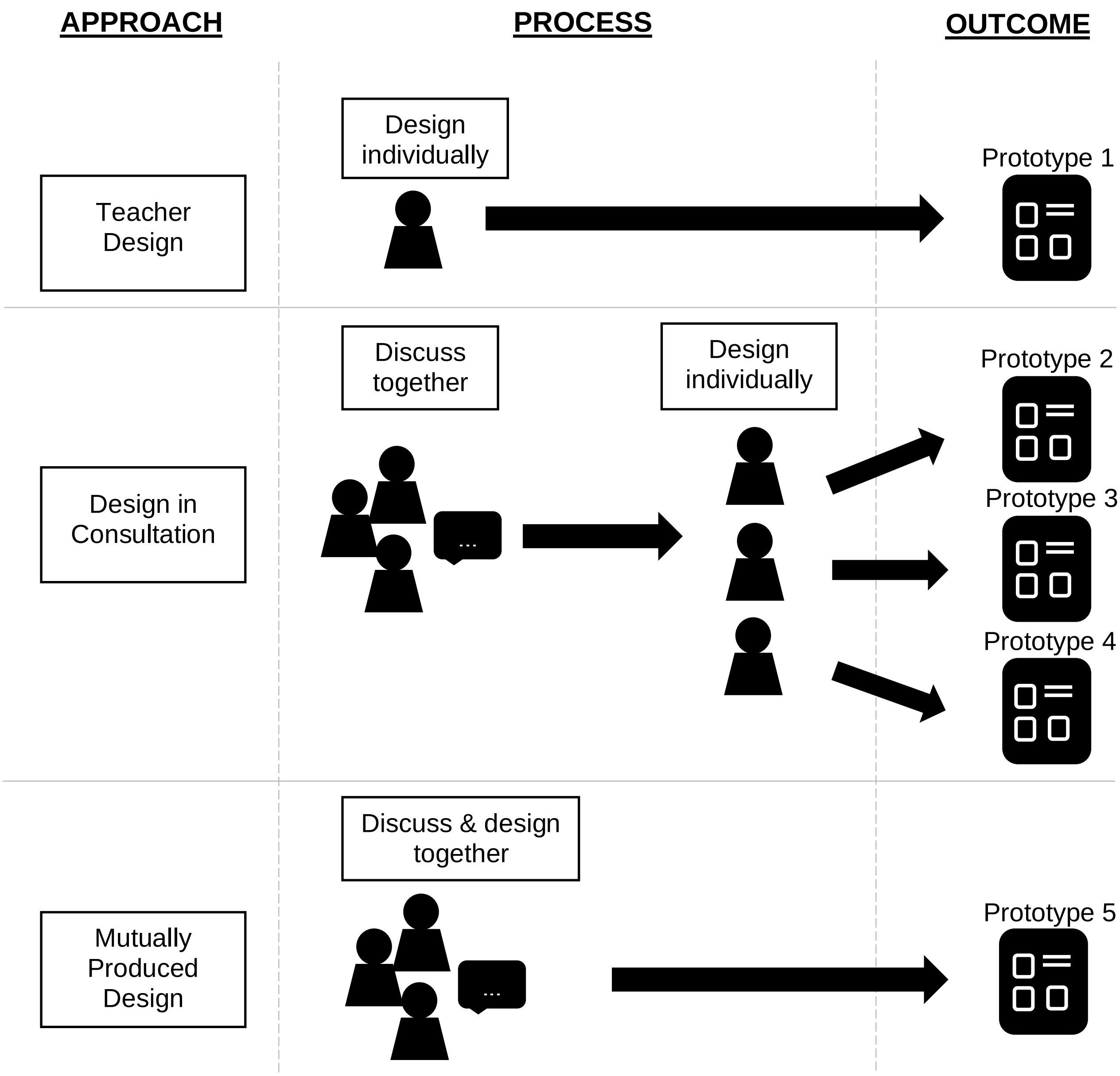

Figure 4-1 Schematic of the three design approaches explored

By comparing these approaches, it helps identify some phenomena attached to the design practice, consultation and the reverse of having students engage in design of the course instead of and in addition to the lecturer.

4.1 Methodology for Design Sessions and Prototyping

The three design approaches were explored through two design sessions (see section 4.1.1). The ideal design sessions may be iterative processes where multiple design workshops are held and longer times are spent on design, but the approach method here captures the effects of discussion and mutual production on design outcomes.

This phase consists of a) design sessions for the low-fidelity prototypes (sketches), and b) high-fidelity prototyping for transforming the sketches into high-fidelity prototypes.

4.1.1 Low-Fidelity Prototype Design Sessions

For the low-fidelity prototypes, two design sessions were held via video conference over Microsoft Teams to produce sketches of an ideal lesson: a teacher design session with the lecturer and a co-design session which included a lecturer and two students, both comprising of an hour each. The researcher held the role of facilitator and was present for both sessions. The facilitator mostly prompted responses from the participants or guided the sessions to ensure it was on track. Questions were also asked by the facilitator to clarify details provided by the designers. At the end of all the sessions, five sketches were produced and observations were recorded.

The researcher prepared for the design sessions by creating Google Jamboards dedicated to each designer in the sessions. The session was introduced and the designers were oriented towards the study as follows:

1. The designers were welcomed and given an overview of the research study.
2. An overview of the current course design and problems in practice were presented.
3. Student expectations and feedback from phase one were presented in table format to the designers (Appendix C).

The design session was then led by the facilitator who instructed the designers to use the Google Jamboards to:

1. Describe the important features of a successful MIT database course.
2. Give an overview of the structure of their ideal MIT module.
3. Individually sketch out a vision on how they would like the course material to be presented to the students using a quick sketch method (either on the Jamboard or using pen and paper, then the designer holds up the sketch to the camera and a screenshot is taken by the facilitator and pasted onto the Jamboard), using MIT Databases Chapter 2 The Relational Model as example material if required.

The teacher design session and co-design session differed as follows:

- **In the teacher design session**, the lecturer was given some pre-design and post design questions. Pre-design questions include: a) what would you change about the current module, b) what would you change about the current lesson plan, c) what do you think the students want improved in the course, and d) what challenges do you face when wanting to change the module. Post design questions include: a) what challenges do you face when implementing these changes and b) were the student requirements as you expected (see Appendix C). Feedback from these questions help with understanding the lecturer mindset.

- **In the co-design session**, the designers had the opportunity to share their responses after each task was individually completed (design in consultation). They also had the additional task of co-designing a sketch together (mutually produced design).

The co-design session in this study is essentially a diverge-and-converge technique, where "diverge" entails the team members working independently to develop individual insights and "converge" where the team shares their individual insights to develop a collective result (Fessenden, 2019).

4.1.2 High-Fidelity Prototyping

For the high-fidelity prototypes, the sketches were transformed into high-fidelity prototypes by the researcher using the lessons feature in Vula. The researcher evaluated the sketches and the functions and decided that the lessons feature on Vula was adequate to reproduce the sketches as high-fidelity prototypes.

The steps taken to transform the sketches are as follows:

1. A project site was created on Vula.
2. A lessons page in the site was created for each sketch.
3. For each element of the sketch, a corresponding element within the lessons page was added as per the sketch layout. For example, a text element was added for a sketch heading, an embedded video was added for a video block in the sketch, etc.
4. HTML code was added for some functions as described by the designer. For example, a link to another page was added using the text element and HTML code.
5. The high-fidelity type was sent to the respective designers for confirmation after it was completed.

4.1.3 Recruitment

Designers were recruited on a voluntary basis. There were some difficulties in setting up sessions for a group of people, mainly due to scheduling conflicts and the limited number of available individuals. Thus, designers were recruited using convenience sampling and participation requirements were access to the internet and access to Microsoft Teams.

4.2 Findings for Design Sessions and Prototyping

4.2.1 Teacher Design

In this section, the sketch and feedback that emerged from the teacher design session are presented.

i. Sketch

The lecturer placed emphasis on the quality of the notes and content when brainstorming the features of a successful course, explaining that "materials must be explained clearly and have useful examples". Other important features mentioned include alignment of assignments and objectives, having timeframes, forums and chat sessions in Vula, as well as assignment feedback (see Table 4-1). Rather than focussing on individual assignment feedback, the lecturer felt it would be more beneficial to provide a one-page feedback to the class of incorrect things done in the assignment so that students learn from each other’s mistakes.

Table 4-1 Summary of the Lecturer’s responses and ideas through the teacher design approach

Response to findings	
Important features of a successful MIT module	• Notes have to be good • Assignments should align with content and objectives • Should have timeframes • List of incorrect things from assignments for whole class so they learn from each other’s mistakes • Material must be explained clearly and have useful examples • The forums on Vula, time to time chat sessions on Vula would be good
Structure of an ideal MIT module	
Learning Material	• One file searchable material, consistent • Reference supplementary material that is not examinable • Chapter outline
Practical Assessment	• Possibly some quizzes • Review questions with answers • 2 assignments that cover all the work, class is too small for group assignments, assignment 2 should not depend on ass1, show best solution to class. Assignments should be practice for exams.
Theoretical Assessment	• One exam at UCT, 2 hour exam but let them carry on 30min after, balance of basics, can you tell me in your own words, applied content of course notes
Communication	• Give one feedback page to class • In chatrooms but perhaps a Zoom/Jitsi meeting for exams and assignments

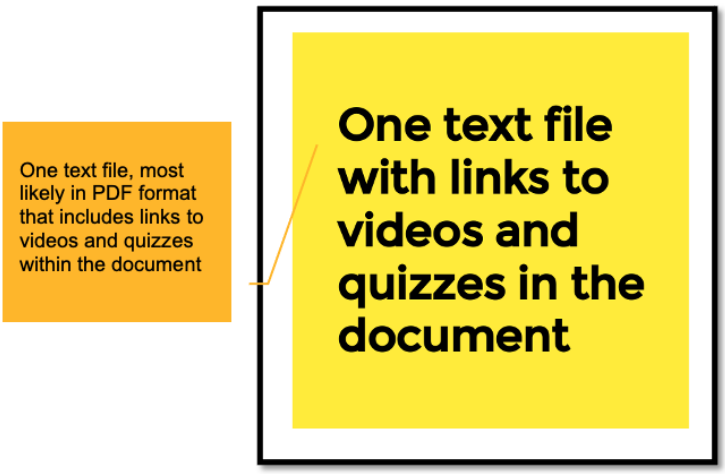

Figure 4-2 Sketch of the Lecturer's vision of learning material presentation of a chapter in a course (teacher design)

The ideal learning material for the lecturer was one file which was searchable and consistent that may reference non-examinable supplementary material, with chapter outlines (Figure 4-2). The practical assessments would be the assignments, review questions with answers and possibly some quizzes. This thought process resulted in the sketch above, where the learning material would be presented as one text file with links to videos and quizzes.

ii. Pre-Design Feedback on MIT Online Course Practices

Prior to design in the teacher design session, the lecturer was asked some questions on improving the current course and the challenges faced to make these changes.

The improvements suggested by the lecturer to the MIT Database course were mostly regarding changes to the learning content, which is beyond the scope of this study. In terms of presentation of the course material, the actionable improvements mentioned were a) PDF pages need to be searchable, b) PDF pages need to be numbered, and c) the review questions in the PDF should be properly labelled. For example, there are questions under the headings "exercises" and "review questions" and the lecturer questioned what the difference was between them. When the lecturer was asked what they thought the students would want improved in the course, the feedback was once again related to the actual course content.

From the lecturer feedback, some of the challenges with regard to changing the current course are a) time and effort involved, b) merging the styles of previous lecturers involved in the course with the current lecturer's style and material, and c) mandate to use only free material.

iii. Post-Design Feedback on MIT Online Course Practices

After the design, the lecturer was asked questions on the differences between their expectations and student requirements, as well as the challenges they faced in implementing the design changes proposed.

The student requirements were as the lecturer expected, however, students wanting intuitive navigation was a surprise to the lecturer.

The challenges faced in implementing the changes proposed by the lecturer include a) time constraints, b) making videos, c) copyright issues if using other links, and d) limited features on Vula (e.g. no interactions with students like with Zoom or Teams, quizzes tool not easy to use).

4.2.2 Design in Consultation

The individual sketches emerging from the co-design session, where the design in consultation approach took place, are rather interesting. Some of the designs encumbers the thoughts and discussions that emerged from the idea sharing process, rather than sticking to what they initially brainstormed on their boards. This resulted in some similar themes addressed by the designs, which are described in this section.

i. Student A Sketch

Student A was most consistent in developing the design. From processing the information to structuring the ideal MIT module, Student A seemed to have captured most of the ideas on her board in the design (see Table 4-2).

Table 4-2 Summary of Student A's responses and ideas through the design in consultation approach

Response to findings	
Important features of a successful MIT module	• Interactive design - combination of text, video, images, examples • Assessments - Being able to test your knowledge with assessments (quizzes, open questions, building your own examples) • Good preparations - having it clear where information can be found (before the course) and having it available in a timely manner • Communications - Being able to interact and communicate with lecturers, TAs, other students (including chat functions, Q/As, pre-assignment/exam sessions) • Clear timelines - Have a clear timeline for the semester for every course including due dates, assessment releases and course materials
Structure of an ideal MIT module	
Learning Material	• Text books • Videos (YouTube general + UCT lecturer videos / recordings) • PPT slide decks
Practical Assessment	• Step by step "how to" assessment based on course material • Practical assessments (build a website, write a code, etc.) • Supporting documents! External
Theoretical Assessment	• Quizzes based on course material • Short open questions after each weekly course material presented including answers
Communication	• Chatroom (Vula, Slack) • Pre-assignment and pre-exam Q/A sessions with lecturer • Half a year 1-on-1s with course convenor • TA communication with <24h response time

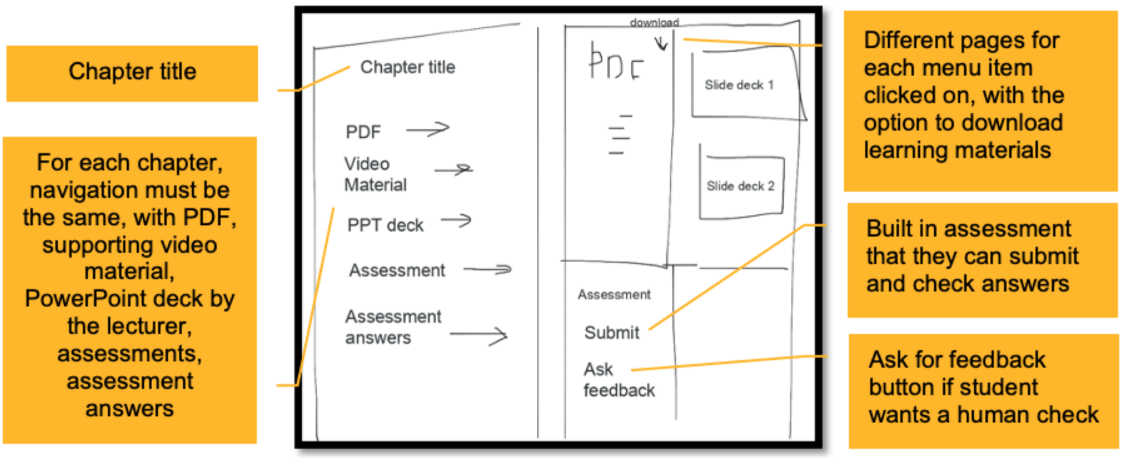

Figure 4-3 Sketch of the Student A's vision of learning material presentation of a chapter in a course (design in consultation)

As can be seen from Figure 4-3, learning materials include PDF, video material and PowerPoint lectures which were all considered important by Student A. Practical assessments are also addressed in the design which was also evident on their idea board. Student A also mentions that an important aspect is the consistency of the layout between all the chapters.

ii. Student B Sketch

The sketch by Student B was influenced by the other designers sharing the ideas on their boards. For example, Student B included PowerPoint and PDF in their design (see Figure 4-4), but this was not mentioned by Student B throughout the idea sharing process (see Table 4-3).

Table 4-3 Summary of Student B's responses and ideas through the design in consultation approach

Response to findings	
Important features of a successful MIT module	• The material will be beneficial in video. Some students prefer an engaged learning experience. Myself included. • I do feel a contact period for students and teachers will contribute to much more interactive environment
Structure of an ideal MIT module	
Learning Material	• Video content lectures
Practical Assessment	• Route to learning especially on code
Theoretical Assessment	• Route to learning especially on code
Communication	• Having an introductory meeting to the module prior to the weeks when assignment is executed

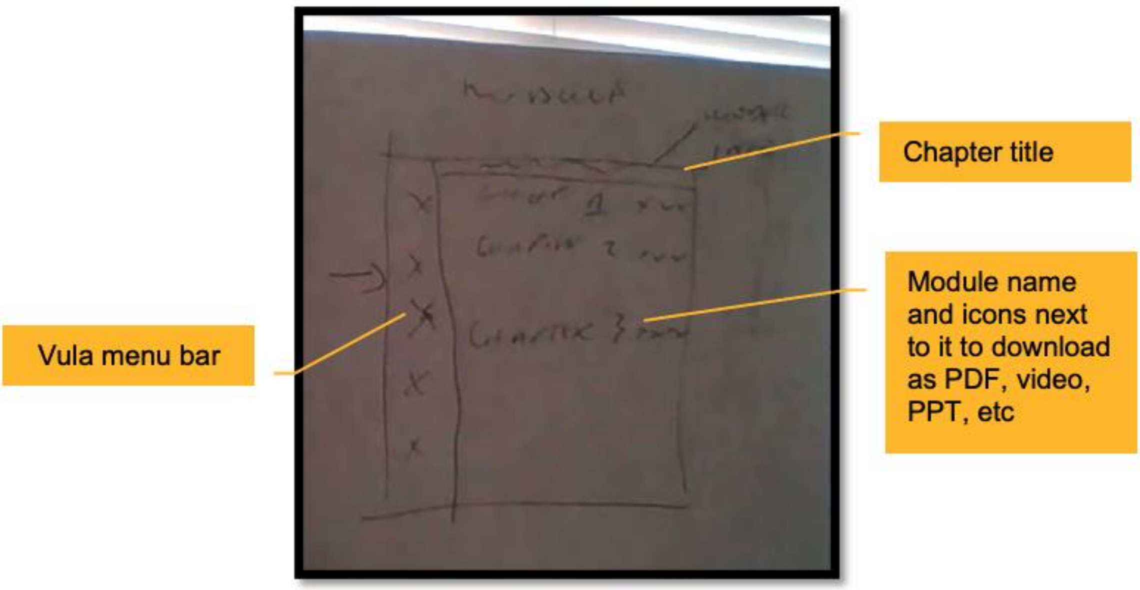

Figure 4-4 Sketch of the Student B's vision of learning material presentation of a chapter in a course (design in consultation)

Video content lectures and a route to learning were most important to Student B. These were reflected in the design (Figure 4-4), where video options are present, and the chapter subtopics have a clear route for users to learn from top to bottom.

iii. Lecturer Sketch

The sketch produced by the lecturer is most interesting here (Figure 4-5), because we can compare it to the sketch produced in the teacher design session. In this iteration, the lecturer appears to have placed emphasis on different features of a successful MIT course, where videos, easier navigation, frequent rapid feedback and communication were mentioned. However, when brainstorming for the ideal MIT module structure, the lecturer stuck with using a PDF with links (see Table 4-4). This was not transferred to the design though.

Table 4-4 Summary of the Lecturer's responses and ideas through the design in consultation approach

Response to findings	
Important features of a successful MIT module	• Videos • Occasional teams/zoom meetings • Camaraderie & sharing/communication • Easier navigation • Frequent rapid feedback
Structure of an ideal MIT module	
Learning Material	• 1 PDF per section (with a few related chapters in it) and each section & chapter starts with outline & objectives/outcomes • PDF notes possibly include links to Vula forum, Vula quiz and Vula online videos at appropriate places
Practical Assessment	• Assignments remain individual as the class is small and there is only time for 2 assignments. They should preferably be application of knowledge
Theoretical Assessment	• Exams should be on campus, as is now. Include handouts of what isn't necessary to memorise eg SQL cheat sheet.
Communication	• I prefer Vula forums for most communication so everything is in one place, and for each assignment & for the exam also a Vula chat session and/or an online zoom/teams session

Looking at the sketch by the lecturer, traces of elements from the idea sharing process can be seen here. For example, during the discussions the idea of a meaningful pathway was mentioned, and the lecturer attempted to put this in the design:

> *"It would be linked to the different videos and that would show the thumbnail what it was on, so it would have a meaningful pathway than it is done now." – Lecturer*

From this process, we can see that the discussions clearly influenced the outcome of the design and made quite a difference when compared to the design in the teacher design session.

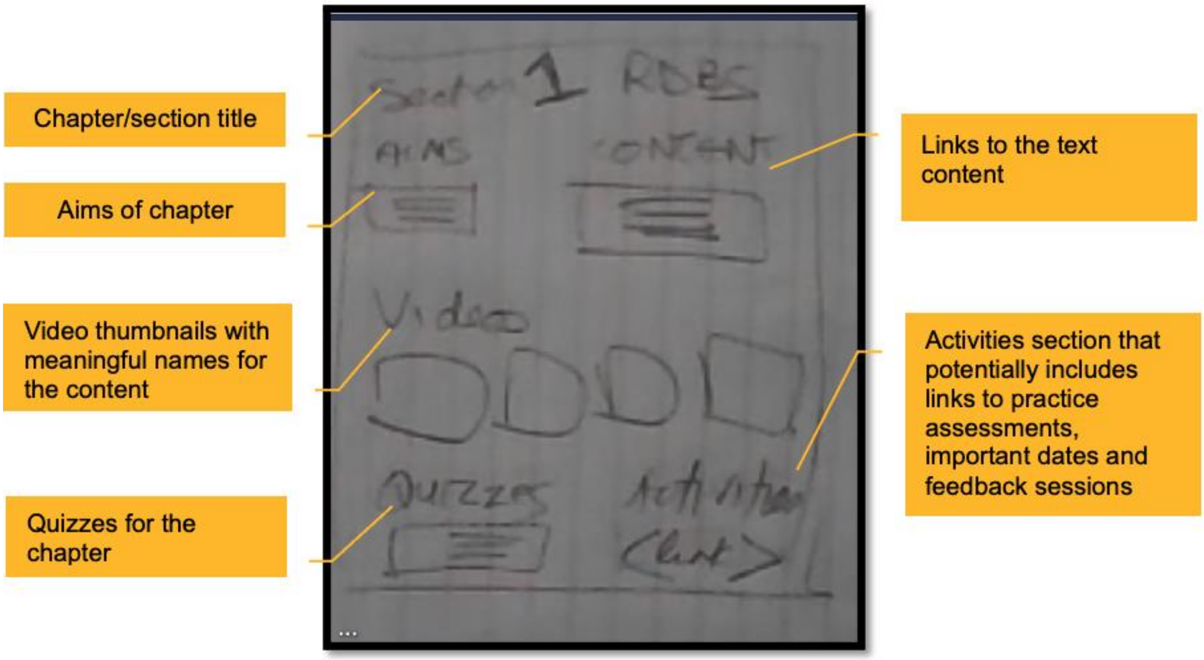

Figure 4-5 Sketch of the Lecturer's vision of learning material presentation of a chapter in a course (design in consultation)

iv. Themes Addressed

There were some similarities between the sketch prototypes produced by design in consultation (see section 4.2.2). Each design consisted of learning material in PDF form as well as links to videos. Each participant also designed their prototype with a page overview.

From the designs and discussions, it was clear that the designers sought to achieve a clear and structured navigation through a page overview. This allows for the user to understand how to navigate through the page with a quick glance and give a "big picture" of what is in the page.

The emphasis placed here was having things "organized" and that the navigation to the different sections or content makes sense. As mentioned by Designer A:

> *"So just as it has a clear overview, and all the material is there, then for me that would be fine. I personally like folders so you have all your folders in one and then you can go into one folder and then maybe there's more folders, but at least that it's organized and you know where to find your stuff and it's consequent across different pages. So every chapter would have the same types of folders and would be structured the same way."* – Student A

This is in line with the student needs where clear navigation was considered one of the most important aspects in a satisfactory online learning platform (see sections 3.2.1 i and 3.3.1 i).

Videos were a “must” for these designers, whether they were links to YouTube videos or a recording of the lectures. Every designer included this as supporting material, indicating that PDFs or a pure text form of the learning content was inadequate. This speaks to the needs of the students where the overwhelming majority of them stated video was their preferred choice of learning and desired multiple representations of material (see sections 3.2.1 ii and 3.3.1ii). Two designers incorporated PowerPoint lectures into their design, which confused Designer C:

> *“I don't know what the difference is between the PowerPoint and the PDF so we can come back to that maybe another time? But I didn't have any PowerPoints. I just had the PDFs, the videos and so forth.”*
>
> *- Lecturer*

One designer had links to quizzes and another designer had links to assignments. These elements would help students cement knowledge and addresses active learning, which was one of the themes that emerged from the previous chapter (see sections 3.2.1 iii and 3.3.1 iii).

4.2.3 Mutually Produced Design

In the mutually produced design, while themes like clear navigation and multiple representation of material were consistent with the design in consultation sketches, two themes that emerged were a three-tier learning process and a pathway to learning.

i. Sketch

When it came to the co-design prototype (Figure 4-6), the designers decided to use the best of the design in consultation sketches (decided by the designers) as the foundation for the co-designed prototype.

Table 4-5 Summary of the co-design team's responses and ideas through the mutually produced design approach

Response to findings	
Important features of a successful MIT module	• Text, videos, examples to learn from • Interactive and engaged learning experience • Assessments to test knowledge • Contact/communication sessions for students and teachers • Clear timelines • Frequent feedback
Structure of an ideal MIT module	
Learning Material	• Videos to learn and explain concepts • PDF text • PowerPoint lectures that inform on important sections
Practical Assessment	• Step by step assessments to create route to learning • 2 individual assignments with application of knowledge
Theoretical Assessment	• Quizzes with answers and exams
Communication	• Response time is important • Chat sessions before important events like assignments and exams • Chatrooms in Vula or Slack

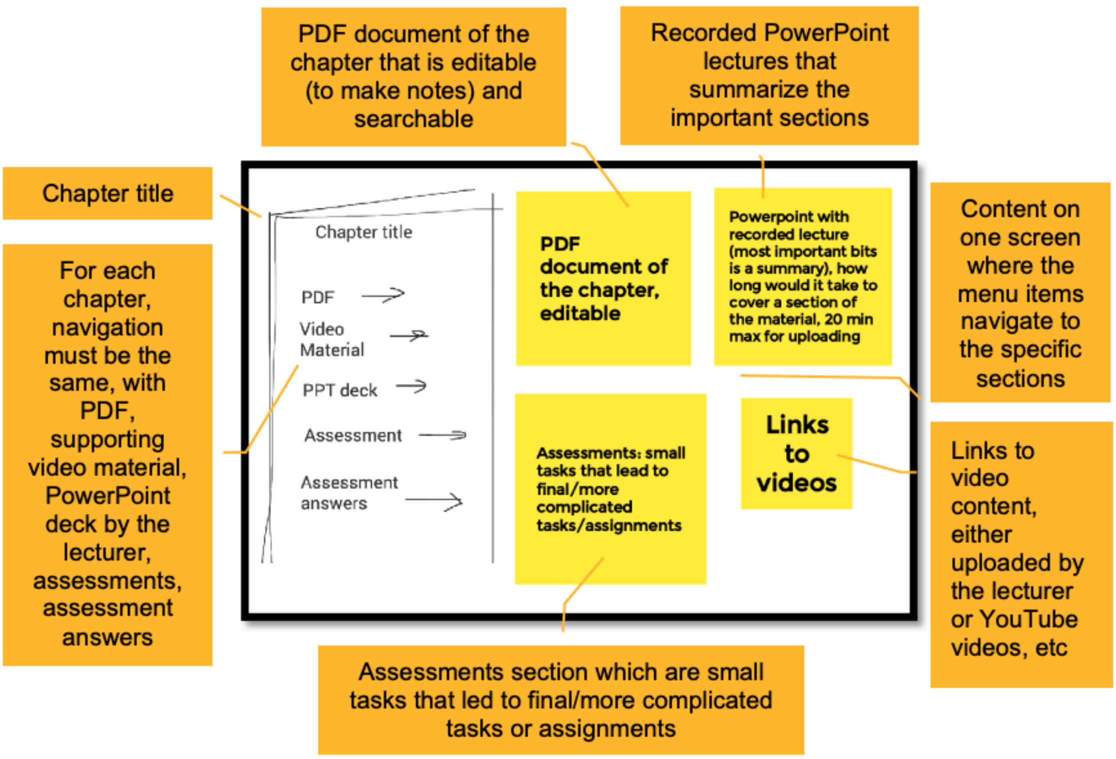

Figure 4-6 Sketch of the co-design team's vision of learning material presentation of a chapter in a course (mutually produced design)

ii. Three-Tier Learning Process

This prototype included PDFs and PowerPoint lectures with audio as the main learning material, with links to videos (see Figure 4-6), which addresses the need for multiple representations of material (see sections 3.2.1 ii and 3.3.1ii). Through the discussions, it appeared that the designers were going for a three-tiered learning process, where PDFs are the anchor and the core learning material, PowerPoint lectures are the summarized versions of what the lecturer considers is important to learn, and the videos are detailed explanations of concepts or topics that would be more easily understood via visual explanation.

The decision to include PowerPoint lectures with audio, or a video of the lecture was so that students understood what material was important to learn, as mentioned by the student designers:

> *"Personally, I feel like what lecturers tend to do is have all their regular lectures on a PowerPoint when they presented to a class so what I always take from it is that what's under PowerPoint is what's considered the most important by a lecturer, so that's why I personally always find it useful, like as a recap of the material supporting the actual lecture video." – Student A*

> *"Because for me it's definitely worth having it but you can't solely base your learning on the PowerPoint slides because a lot of times those PowerPoint presentations have lecturers talk to it, so not all the information resides on those slides for that particular topic, but it's definitely worth it having it there to inform what material that's available to you via the PDF documents and stuff." – Student B*

In other words, the PowerPoint with audio would be like a lecture video and a summary of the detailed lecture notes. The emphasis is on the PowerPoint showing the sections considered important by the lecturer.

The videos would either be internal or external, for example videos recorded by lecturers or from YouTube. The length of the videos would depend on the lecturers and their convenience. The discussion around the video length was a "difficult" one because while they can consider many factors, such as how long it takes to cover the material or the attention span of students, it is eventually dependent on the lecturer.

The PDF notes are the core materials that cannot be done without. It was important that these documents were put together well, so that it was easily searchable and navigable, embracing the theme of clear navigation per previous chapter (see sections 3.2.1 i and 3.3.1 i).

iii. Pathway to Learning

In the prototype (Figure 4-6), the designers also included a quiz or assessment section, where these assessments are small tasks related to the material covered in the section.

These small tasks or assessments would eventually lead to the bigger assignments. The designers considered this a "pathway to learning", where these small assessments direct the path of the learner and assess their understanding. This addresses the theme of active learning, which was one of the student priorities (see sections 3.2.1 iii and 3.3.1 iii).

4.2.4 Observations

Through this design process, the researcher made some observations of the interactions between the designers during the design sessions. Observations regarding the design output and the way different designers interpreted themes in their sketches were also noted.

i. Design Sessions

During introductions in the co-design session, the participants were very brief and did not provide any more details about themselves except their names. Due to time constraints, there was no time to build rapport. Nearing mid-session, the participants started to share their experiences in the course and interact with each other without being prompted, providing details like their struggles voluntarily and giving responses to each other's suggestions, suggesting that they were becoming comfortable with each other.

It was observed that the lecturer mostly asked questions related to the learning materials for their particular course, suggesting their focus was on the course that they were teaching. The students would share the problems that they encountered with the MIT modules and focused more on discussing these.

The lecturer and students were quite understanding of the difficulties that each faced as a lecturer or student. Through the co-design session, they were exposed to the challenges that each faced in their roles and gained a wider perspective on these.

Although presented with the data from the interviews as to the student requirements, the designers still had a tendency to encompass their own individual perspectives in their designs. For example, while the consensus from the student requirement elicitation phase suggested that students would like more active learning (e.g. quizzes and assessments, see section 3.2.1 iii and 3.3.1 iii), not all the designers put this into their design.

ii. Interpretation Differences

While the sketches had a lot of similarities in terms of type of presentation of material, the differences came in how the individuals and the team interpreted themes such as "clear and structured navigation" and "pathway to learning". For example, the lecturer sketch produced by the design in consultation approach (Figure 4-5) represented "pathway to learning" as video thumbnails linking to the chapter, while in the mutually produced design sketch, the assessments were considered as directing the path to learning by assessing student understanding through the chapters.

Clear navigation was also interpreted differently by each designer. For some designers, organization and consistency between chapters were the keys to structured navigation (see section 4.2.2 i). On the other hand, some designers consider structured navigation to be a clear, numerical presentation of topics in the chapter (see section 4.2.2 ii).

4.2.5 Sketch to High-Fidelity Prototype Transformation

This section shows the transformation from the sketches to high-fidelity prototypes. The layout, labels and content were taken directly from the sketches, as well as taking the explanations of the designs by the designer into consideration. The following diagrams serve as an example of how these sketches were translated into Vula.

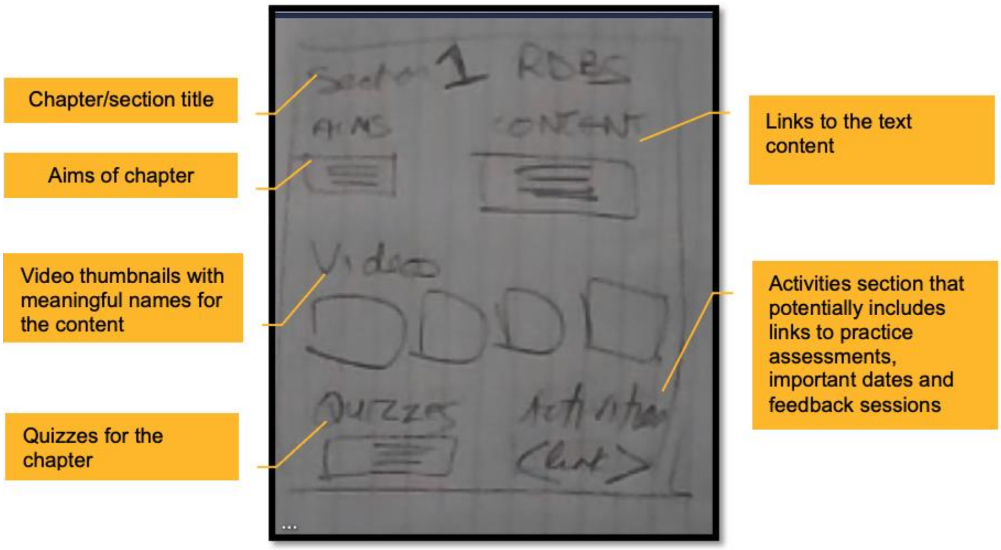

Figure 4-7 Sketch with notes of the designer's vision

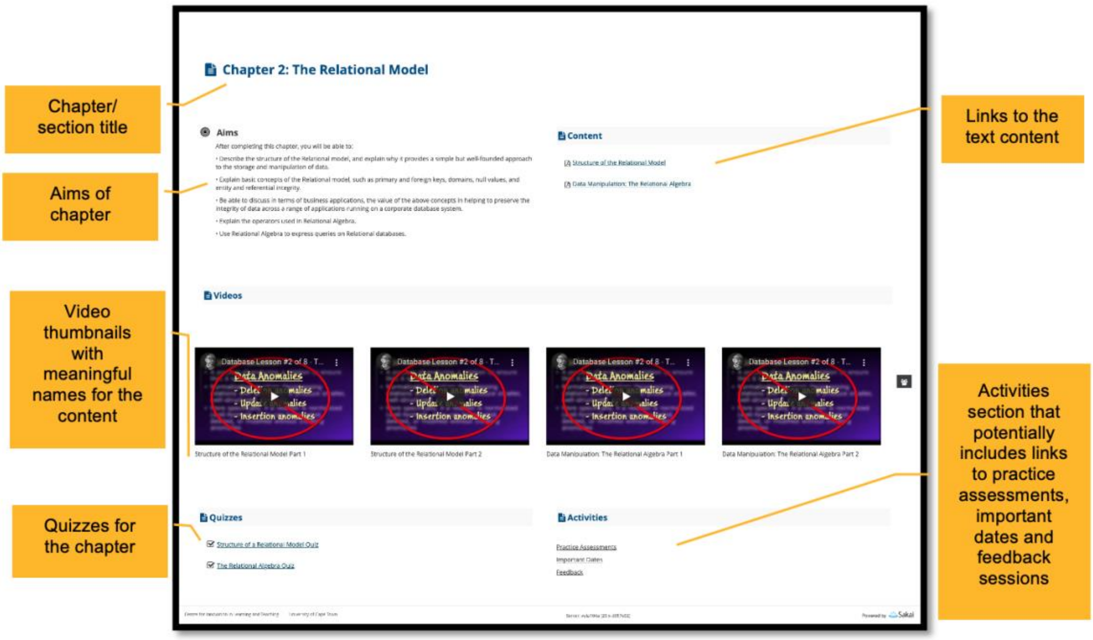

Figure 4-8 High-fidelity prototype of the designer's sketch with corresponding notes of the designer's vision

The chapter or section title is located on the top as per the sketch as heading text (see Figure 4-7 and Figure 4-8). Aims of the chapter and links to the text content are arranged next to each other. Video thumbnails with meaningful names for the content are placed below this. Finally, in the fourth row, quizzes and activities and the respective content are next to each other as per the sketch.

All the sketches were transformed onto Vula, using the same font, font size and the content was kept the same where possible (e.g. the same YouTube video was used for a video element, same PDF was used for a PDF element). In addition to functionality, Vula is familiar to the students evaluating the prototypes and eliminates the need for students to learn a new platform.

The remainder of the design transformations are located in Appendix A.

4.3 Discussion for Design Sessions and Prototyping

4.3.1 Analysis of Approaches to the Design and How Deviation from Student Priorities Emerge

This “diverge” stage (see section 4.1.1) enables divergent thinking, where various ideas emerge cognitively in an unorganized manner (Guilford, 1956). Divergent thinking also occurs due to external input, such as when the team members mentally process the ideas from each other in the design in consultation approach. This is followed by convergent thinking, where the team members organize this information and develop it into a single output (Guilford, 1956), in this case their individual sketch through design in consultation. These thinking processes are evident in the designs where the design in consultation sketch differed from the ideas that emerged in the “diverge” stage of the process (see section 4.2.2).

As evident from the processing information (diverge) stage of the design in consultation approach, deviations from student priorities had already emerged (see section 4.2.2). Even though the designers were given the same information, the information taken in by each designer and what they considered important differed from each other. Deviations also came in with the way each designer interpreted the information and translated it into the design (see section 4.2.4 ii), giving further support that deviations exist due to divergent thinking.

However, the discussions that took place in the co-design session enabled the individuals to broaden their perspectives and add to their own ideas. These discussions and idea sharing stages brought about new thinking in some of the design in consultation sketches (see section 4.2.2). Dow et al. (2010) found that when people create multiple alternatives in parallel, the output is higher-quality and more-diverse. This can be extended to the case here, where alternative ideas from team members encouraged more diverse sketches that incorporated more online learning themes such as multiple representations of material found in the previous chapter (see section 4.2.2 iv). The comparison of the sketches produced by the lecturer through teacher design (Figure 4-2) and design in consultation (Figure 4-5) is evidence of this. From the design process, we can see that had the idea sharing stages not taken place, the second iteration by the lecturer would not have been much different.

The mutually produced design was “chosen” rather than “designed” in the co-design session. This design approach resulted in a sketch that was similar to one of the design in consultation sketches and seems to have hindered creativity. This was also the case in the study done by Trischler et al. (2018), where they found that co-design can sometimes diminish outcomes. However, the discussions around the co-design did bring about themes such as a “three-tiered learning process” and a “pathway to learning” that contributes to deeper understanding of design thinking.

4.3.2 Factors that Affected Collaboration

These sessions were held during the COVID-19 pandemic, when a national lockdown was implemented at one stage or another for different provinces and countries, restricting travel and in person meetings; hence it was conducted electronically. This resulted in some technical constraints such as unclear audio, poor visuals, and presentation issues, which may have hindered collaboration.

In an ideal co-design session, it would be in person, about two and a half hours long, have physical co-design materials to use and be in an environment where it is possible to build rapport. However, due to the circumstances, this was not possible. The session was conducted over Microsoft Teams and participants had to make use of Google Jamboard for the design session, which they were unfamiliar with. This could have inhibited their design potential as an individual and as a team. The co-design cohort also did not have time to build rapport before commencing with design. Without relationship building, the participants could have withheld some of their truer perspectives or feared speaking up.

Time constraints were also one of the factors that affected collaboration. Each participant had a full-time job in addition to their part-time studies, and this had to be balanced with the shift to remote work due to the COVID-19 pandemic. This limited the co-design to an hour session and a more rigid co-design process.

The co-design session in this study is therefore not representative of typical co-design practices. However, this design process made it possible to witness how deviation from student priorities emerged from different design approaches, and illustrated the impact of divergent thinking from internal and external influences on design.

5 Prototype Evaluations

This chapter focuses on the student evaluations of the high-fidelity prototypes developed in Chapter 4 and addresses the question: *how do different design approaches affect the outcome of an artefact and user satisfaction in the online learning context?*

The prototype evaluations are summarized in this chapter and discussed in relation to the findings from Chapter 3 and 4. By understanding the design trajectories that emerge with the participation of students in design, it helps identify the phenomena that may contribute to deviation of design outcomes from student needs.

5.1 Methodology for Prototype Evaluations

A combination of cognitive walkthrough and interview was used for the prototype evaluations. Cognitive walkthrough provides a quick way for users to understand the interface functionality (Dix et al., 2004), and interviews help with observing the sentiments and thoughts of the evaluator. Each combined session of the cognitive walkthrough and interview with the evaluators was about 30 – 45 minutes long.

5.1.1 Cognitive Walkthrough

The evaluators were first briefed on the purpose of the prototypes and evaluation. After the introduction, evaluators were shown each prototype sequentially via Zoom and allowed to explore the prototype briefly. An approach similar to counterbalancing, Latin square, was used to show the prototypes and minimize order bias ("Latin Square Designs," 2008). For each prototype shown, the participants were asked to:

- Describe their study strategy usually, preparing for assignments and exams using the presented prototype and the materials provided
- Evaluate the design based on their learning needs
- Evaluate the designs based on the online learning themes

The cognitive walkthrough questions are given in Appendix D. Some of the strengths of cognitive walkthrough include saving time and allowing quick responses and decision-making, among others. It is useful for identifying potential problems and determine how easy a product is to learn.

5.1.2 Interviews

The cognitive walkthrough was followed by a semi-structured interview to understand what was observed in the cognitive walkthrough and the evaluator's overall view of the prototypes. Some example questions were: a) did any particular design suit your needs and b) rank the designs and describe your reason for the ranking (for full set of questions, see Appendix D).

One of the main strengths of interviews is that it allows the interviewer to capture the behaviour and emotions towards the prototype. In addition, the interviewer can keep the interviewee focused and extract useful answers out of them if their behaviour shows a loss of interest.

5.1.3 Data Analysis

Coding was used to analyze the qualitative responses. For the cognitive walkthrough and interviews, the transcripts were imported into the NVivo 12 package and coded based on the evaluator likes and dislikes. Outliers or interesting points were noted down.

Descriptive statistics was used to evaluate the quantitative data. For ratings, the mean and standard deviation were used, since Likert-type items with a length of 5 numerical responses may generally be treated as continuous data (Harpe, 2015). For the ranked data, the mean, standard deviation and Friedman test were used, which ranks scores within each group and calculates a test statistic from rank sums (Zimmerman & Zumbo, 1993).

5.1.4 Recruitment

Five evaluators were recruited to obtain a fair amount of responses that can represent the diversity, taking into account the population, goals of the study and simplicity of the prototypes (Alroobaea & Mayhew, 2014; Dumas & Redish, 1999; Tullis & Albert, 2013). The criteria for participation include a) access to the internet and a device to clearly view the prototypes, b) location, where evaluators are either based in Cape Town with access to campus, or elsewhere and have no access to campus, c) are currently enrolled or have enrolled in the MIT course, and d) has enrolled in at least one online course before. Convenience sampling was used for recruitment due to COVID-19 constraints. The evaluations were done on a voluntary basis with no incentive to ensure the feedback was genuine and not incentivised.

5.2 Findings for Prototype Evaluations

This section summarizes the evaluations of each prototype and observations made. Each prototype and its evaluation are first presented according to the design approach (sections 5.2.1 - 5.2.3), then evaluations are summarized in a comparable format (section 5.2.4). The prototype designs are labelled as follows:

Table 5-1 Design prototype name and details of the corresponding designer

Design	Designed by
CODESIGN1	Mutually produced design, co-designed by lecturer and students
LECTURER1	Teacher design, individually designed by lecturer – first iteration
LECTURER2	Design in consultation, individually designed by lecturer – second iteration
STUDENTA1	Design in consultation, individually designed by student A
STUDENTB1	Design in consultation, individually designed by student B

5.2.1 Teacher Design

LECTURER1 (Figure 5-1) was not well received by the evaluators. The evaluators disliked that there was no engaging content, does not attract the learner, additional learning materials (such as video) are not clearly visible and that they had to search for links within the PDF. As one evaluator mentions:

> *“So, if I had to learn from a site like that, I would be probably very disappointed. There’s nothing to work with than a PDF textbook chapter that the instructor took just as it was and presented it to the learners. I don't exactly know what you are supposed to learn from this chapter as a student of a specific course. And it is a bit confusing*

to have to look for links within a PDF, which is like not the nicest thing to do." – Evaluator 2

Dissatisfied comments like "oh no, this is my worst one" and "not ideal" would appear when the evaluators were exploring this design. The evaluators mostly felt LECTURER1 was basically a textbook placed in a web interface.

Even though the PDF in the design consisted of links to videos and quizzes, the evaluators felt there were two issues with this:

1) Students are not sure when these links would appear in the document and would literally have to hunt for them
2) It would be tedious to look for these links again in a document full of text if the student needed to refer back to it

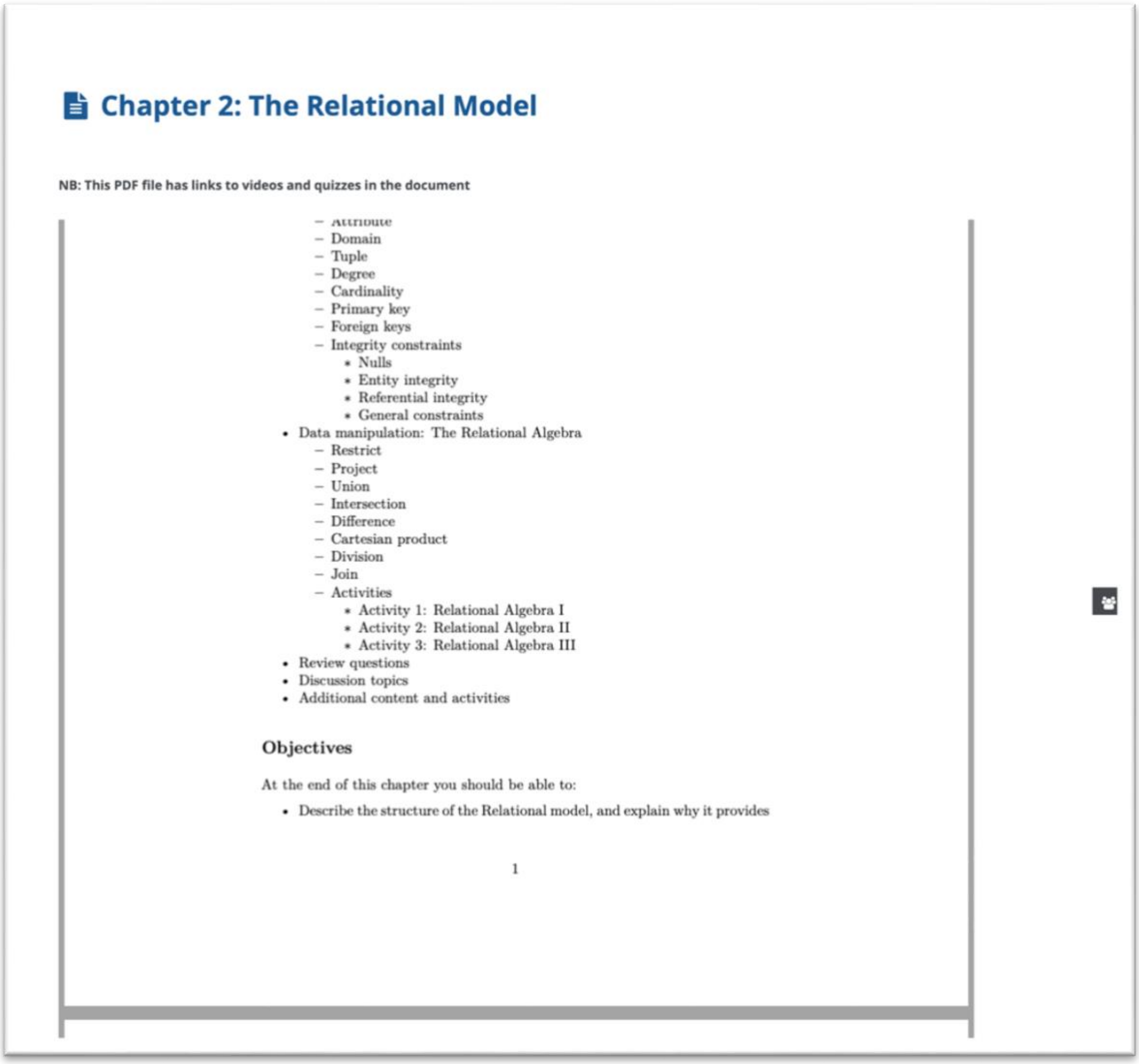

Figure 5-1 LECTURER1 High-fidelity prototype of Lecturer's design through teacher design approach for evaluation

Table 5-2 Evaluator ratings of LECTURER1

	Evaluator Ratings					Average Rating	Standard Deviation
Satisfy Student Learning Needs	1	2	3	2	1	1.8	0.8
Satisfy Online Learning Factors	1	1	4	2	1	1.8	1.3

1 – Not satisfied, 2 – Somewhat satisfied, 3 – Satisfied, 4 – Quite satisfied and 5 – Very satisfied

Only one evaluator gave LECTURER1 a satisfactory score in terms of satisfying their learning needs (see Table 5-2). However, the reason was not particularly because of the design but rather an acceptance of whatever was provided:

> *"I'll say I'm satisfied because of the links and the video. There aren't any dislikes really. It's just that it's just the same as what we get, so it's just like, OK I'll accept my fate." – Evaluator 3*

This design was also considered text-heavy with no clear objectives and goals for the chapter and no engagement.

> *"When I see so much text I'm really discouraged as a learner. It's not fun for me to engage with. It will be more fun to have the objectives in a video. At this point you don't even know what the listed topics even mean." – Evaluator 5*

Overall, the evaluators gave this design a low score and deemed it unable to meet online learning requirements (see Table 5-2).

5.2.2 Design in Consultation

This section summarizes the evaluations for the designs produced by the design in consultation approach.

i. STUDENTA1

STUDENTA1 (Figure 5-2) was praised for having multiple representations of content, assessments which provide opportunity for interaction, feedback in the form of assessment answers and easy navigation. It was criticized for not having clear goals and expectations for learners that were clearly visible to the students and no chat option within the interface.

> *"The clear goals and expectations for learners is missing but I assume it's in your PowerPoint presentation or course outline, but I don't actually see it anywhere here. It's got multiple representations of course content, which is good, frequent opportunities for active learning is good because you've got your assessments, frequent and constructive feedback – that's your assessment feedback which is useful." – Evaluator 1*

While some evaluators assumed that these would be in the PowerPoint or in the actual learning materials, majority of the evaluators did not make such an assumption and considered it was a flaw in the design.

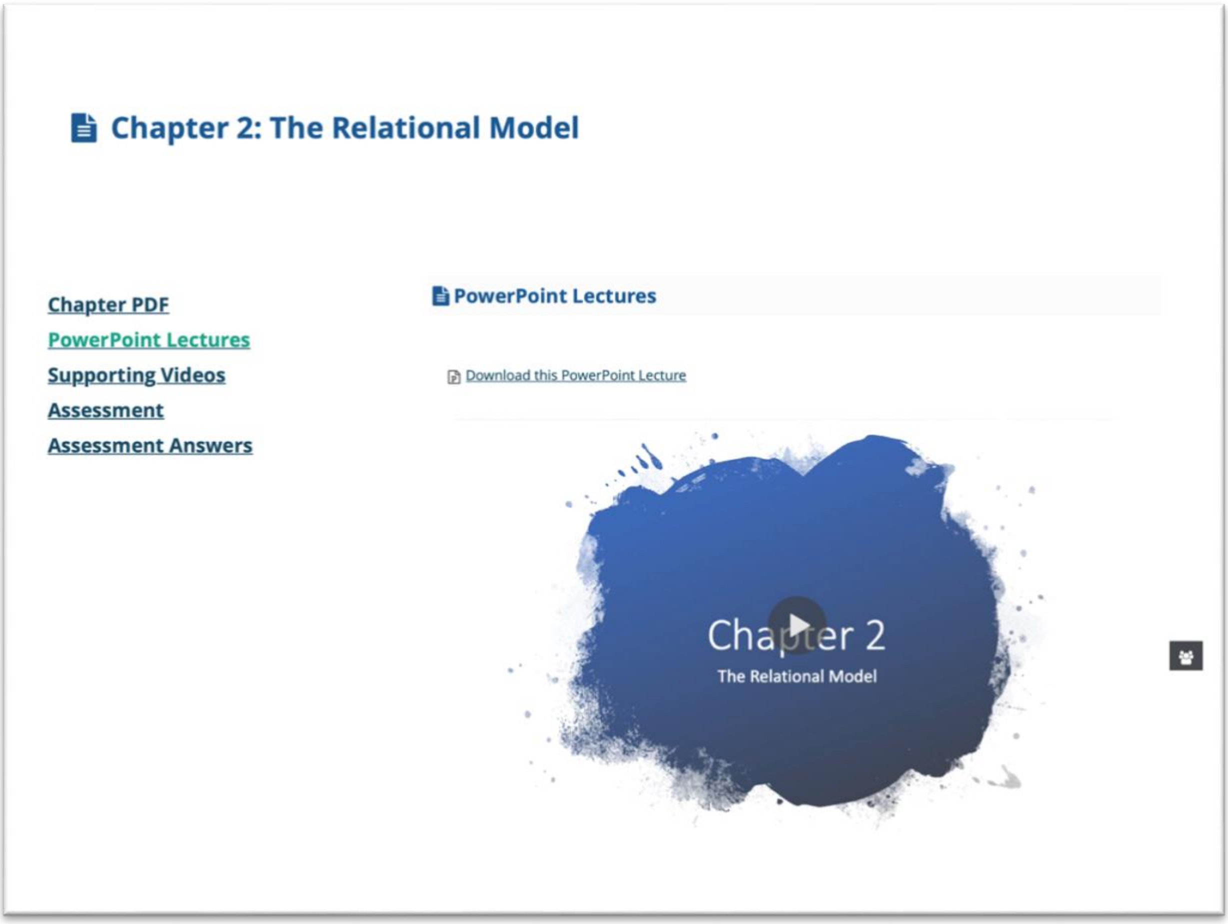

Figure 5-2 STUDENTA1 High-fidelity prototype of Student A's design through the design in consultation approach for evaluation

Table 5-3 Evaluator ratings of STUDENTA1

	Evaluator Ratings					Average Rating	Standard Deviation
Satisfy Student Learning Needs	2	4	5	4	4	3.8	1.1
Satisfy Online Learning Factors	2	4	5	3	3	3.4	1.1

1 – Not satisfied, 2 – Somewhat satisfied, 3 – Satisfied, 4 – Quite satisfied and 5 – Very satisfied

The structure was considered simple with a menu overview of what is available and well segmented. However, more than one evaluator pointed out that the prototype did not guide the path to learning and they would not know where to start:

> *"It doesn't exactly give me the flow, like this is what I expect you to do, you do ABC, you read the PDF, you answer the questions." – Evaluator 4*

On the other hand, some evaluators expected the PowerPoint lectures to be a guide and the starting point. This was generally the case for the prototypes which had PowerPoint lectures.

On average, the evaluators were satisfied with the prototype to meet their learning needs, as per ratings in Table 5-3.

ii. STUDENTB1

Although STUDENTB1 (Figure 5-3) had multiple representations of content and considered well-structured in terms of the listed chapter modules, the evaluators generally viewed this interface as a “repository of data files”.

> *“It just has multiple representation of the course content and it's just that it doesn't really give much.” – Evaluator 3*

They were particularly unsatisfied with its lack of interaction and assessments, oversimplicity, and inability to facilitate learning but praised it for its simplicity of use. It was considered ideal if they were just using it to download content:

> *“I like that it gives you the PowerPoint, the video and the PDF but my dislikes are there’s no interaction with it. I mean your PowerPoint tells you what you need I guess, but other than that? I mean, it's just it's the same, it's basically just giving us all the material again. There’s no practice material or anything to tell me if I actually understand the material or I’m just understanding it in my own head. I would say I’m somewhat satisfied.” – Evaluator 1*

> *“I'm not looking at it as an e-learning platform, but if I just wanted to get some information in and out then I think that can work.” – Evaluator 4*

One evaluator thought this design had potential to become truly satisfactory.

> *“I wish I could just click here and it would play, it would be good if it was embedded into the webpage. It’s very simple for me to fetch the content I need. I’m satisfied because I have the materials I need to study. It’s simple to use.” – Evaluator 5*

They liked the clear flow of the chapter modules but would have preferred embedded content rather than only having the option to download.

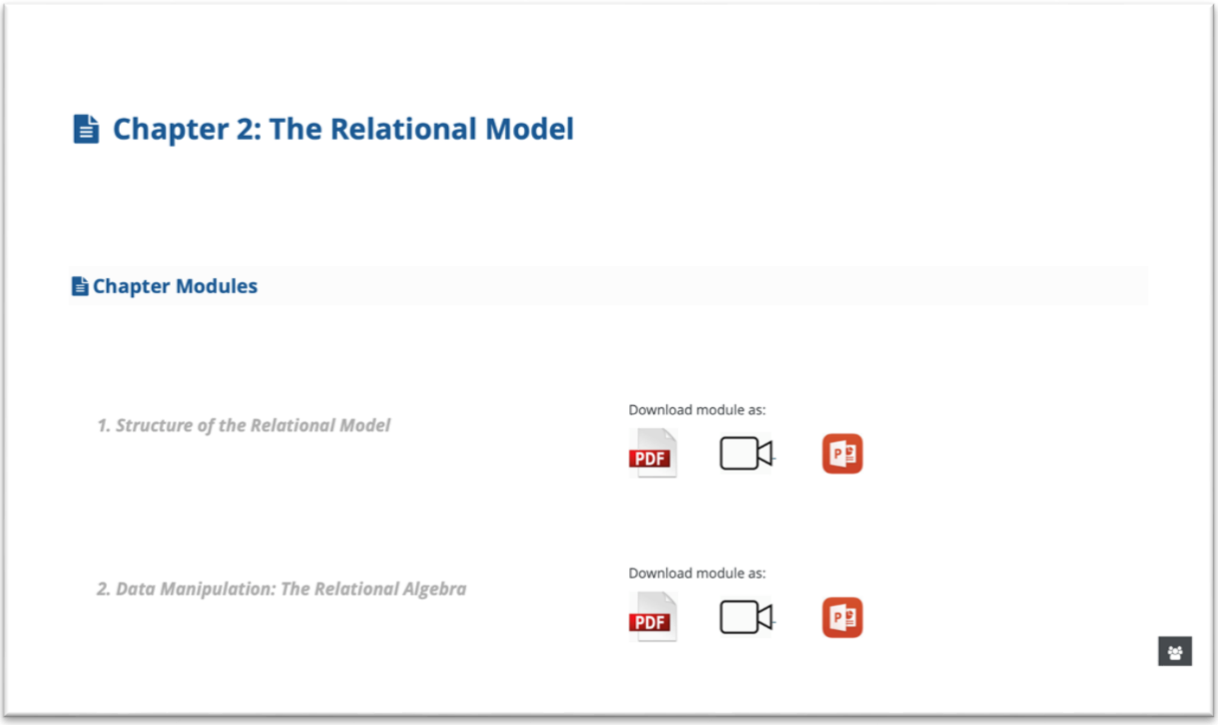

Figure 5-3 STUDENTB1 High-fidelity prototype of Student B's design through the design in consultation approach for evaluation

Table 5-4 Evaluator ratings of STUDENTB1

	Evaluator Ratings					Average Rating	Standard Deviation
Satisfy Student Learning Needs	2	2	4	3	3	2.8	0.8
Satisfy Online Learning Factors	1	1	3	2	2	1.8	0.8

1 – Not satisfied, 2 – Somewhat satisfied, 3 – Satisfied, 4 – Quite satisfied and 5 – Very satisfied

Overall, the evaluators gave it a somewhat satisfactory rating in terms of satisfying their learning needs but considered it unable to incorporate online learning themes (see Table 5-4).

iii. LECTURER2

The evaluator comments for LECTURER2 (Figure 5-4) were generally positive. LECTURER2 was the preferred design for most of the evaluators, mainly due to its structure and ability to satisfy the requirements for online learning. Most of the evaluators were impressed by the upfront aims provided on the design as it set expectations for what the students needed to know by the end of the chapter.

> *"This one is the best actually, I think, because I think it's nice to have the aims and objectives at the beginning because you can prepare yourself in terms of what you need to get at the end. I would go*

through the aims, then I would go through the videos and I would go through the PDFs later." – Evaluator 3

However, they did not like that there was nowhere to make notes, and that they cannot interact with the instructor on the interface. Three evaluators mentioned that it would have been ideal if the interface guided the learning process more.

"It doesn't exactly facilitate learning. It just adds that extra aim." – Evaluator 2

For example, two evaluators suggested that rather than have quizzes and feedback at the end of the chapter, it would have been better if assessments were given after each phase of learning or video.

"The goals and expectations are clear at the beginning of the chapter and it has that feedback at the end with regards to the assessment, but that's only at the end, and not during each phase of learning." – Evaluator 2

Overall, the evaluators were satisfied with this prototype (see Table 5-5).

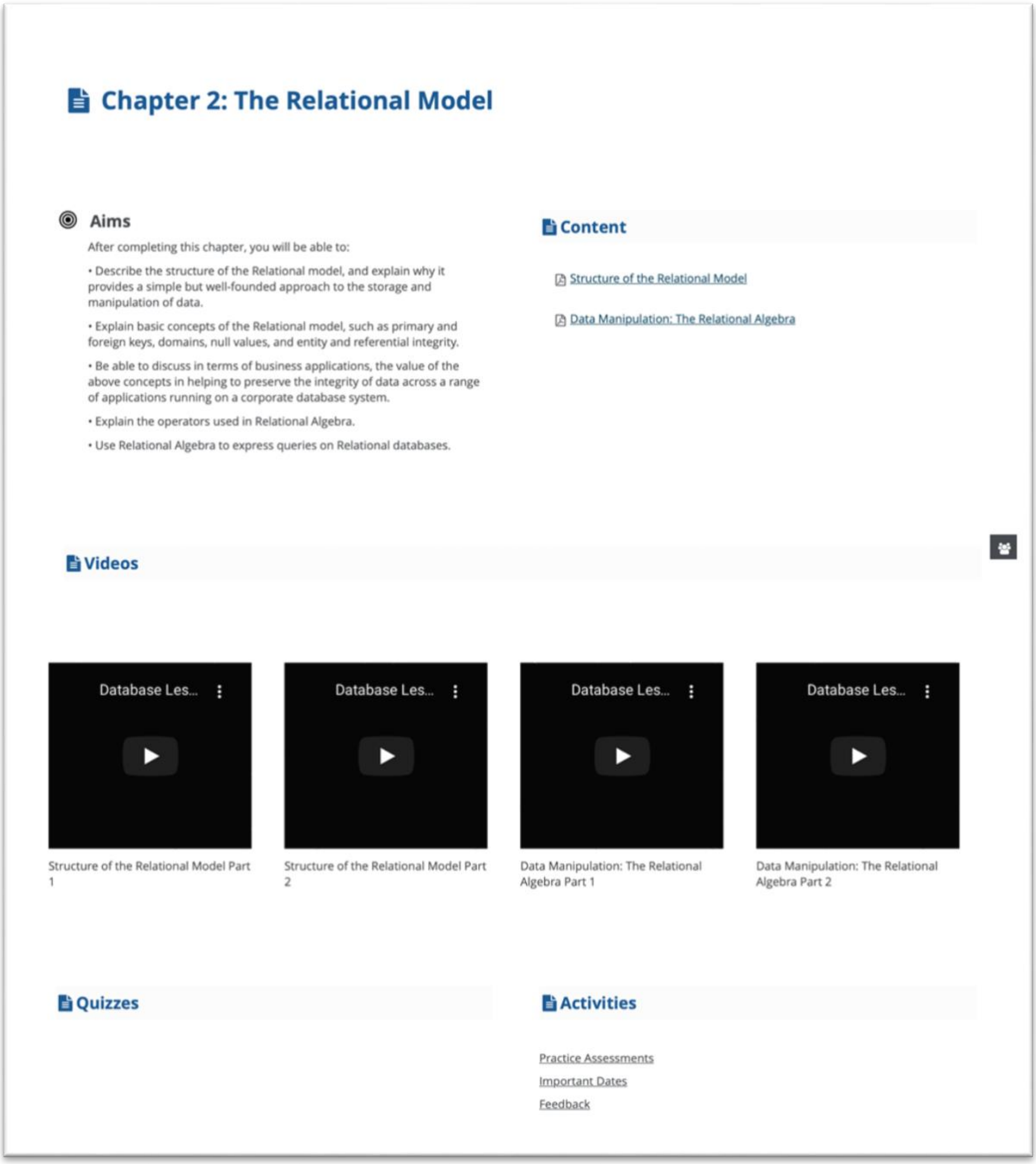

Figure 5-4 LECTURER2 High-fidelity prototype of the Lecturer's design through the design in consultation approach for evaluation

Table 5-5 Evaluator ratings of LECTURER2

	Evaluator Ratings					Average Rating	Standard Deviation
Satisfy Student Learning Needs	2	4	5	4	3	3.6	1.1
Satisfy Online Learning Factors	3	4	5	4	3	3.8	0.8

1 – Not satisfied, 2 – Somewhat satisfied, 3 – Satisfied, 4 – Quite satisfied and 5 – Very satisfied

5.2.3 Mutually Produced Design

The evaluators found CODESIGN1 (Figure 5-5) to be satisfactory in terms of multiple representations of content, active learning option (quizzes) and ease of navigation (side menu to navigate through the materials). There were mixed opinions about the structure, where some evaluators liked the structure and thought it was “easy to use”. However, two evaluators mentioned that the design was too clustered with no focus. For example, the PDF document and PowerPoint lecture were next to each other in the layout, but the evaluators did not see the point of this:

> *“I like the fact that it has the fundamentals that I need, so it has the video content that I need to go through, it has supporting reading materials. It’s just that I don’t like the structure. I would rather focus on one thing, focus on one element.” – Evaluator 5*

> *“And also, the PDF and PowerPoint are side by side - it creates a very full screen that could be overwhelming as well.” – Evaluator 2*

Once again, this design was also considered as lacking a guided path for learning:

> *“I think it's quite nice as it has lot of content to work with and a lot of content to grapple with. But again, there is no guided path on where to begin and where to end.” – Evaluator 2*

In fact, this was a recurrent theme in most of the designs, where the responsibility of structuring the learning is given to the student rather than being guided by the interface.

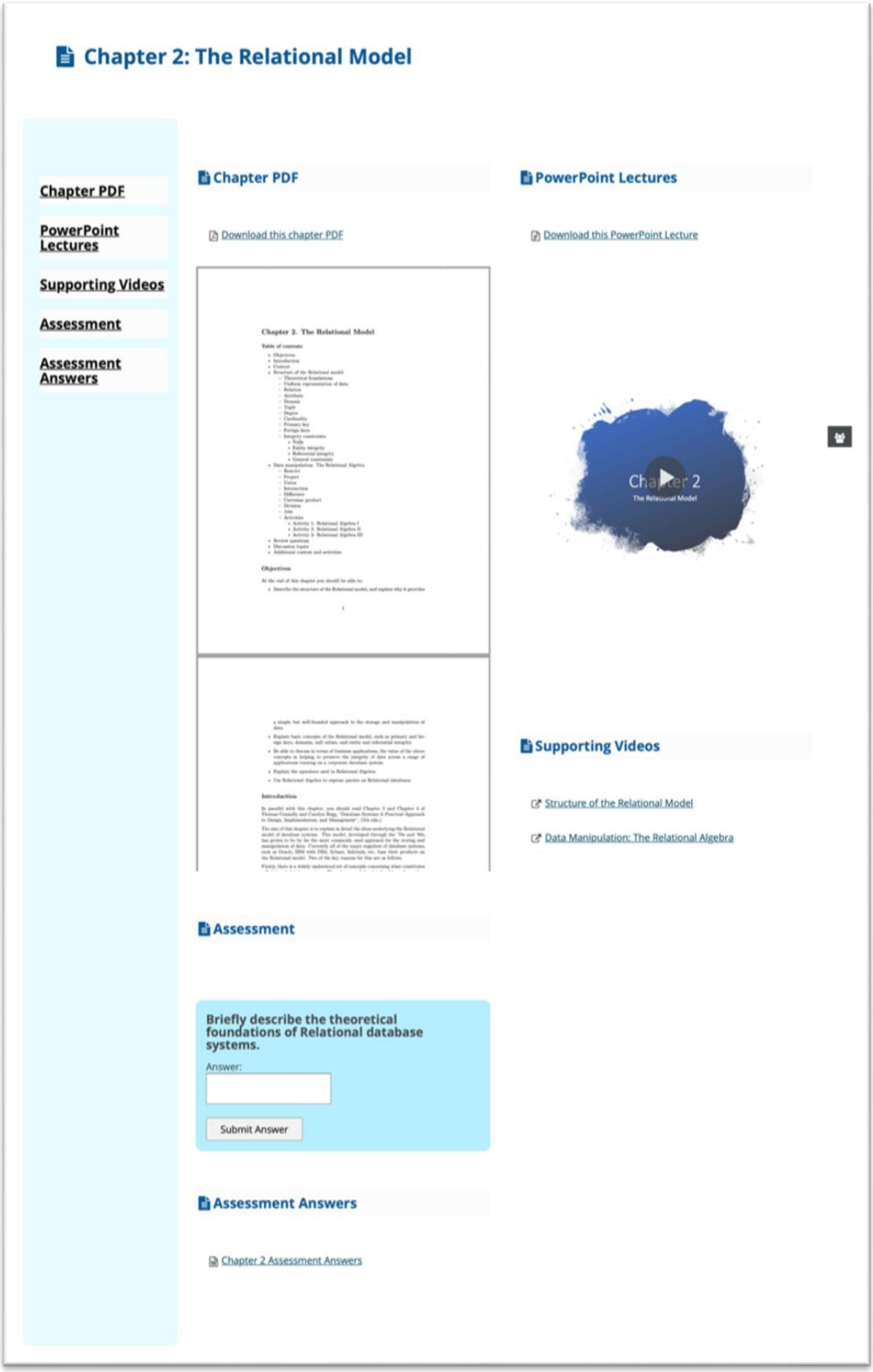

Figure 5-5 CODESIGN1 High-fidelity prototype of the co-design team's design through the mutually produced design approach for evaluation

Table 5-6 Evaluator ratings of CODESIGN1

	Evaluator Ratings					Average Rating	Standard Deviation
Satisfy Student Learning Needs	3	4	5	4	3	3.8	0.8
Satisfy Online Learning Factors	3	4	5	3	2	3.4	1.1

1 – Not satisfied, 2 – Somewhat satisfied, 3 – Satisfied, 4 – Quite satisfied and 5 – Very satisfied

Some evaluators assumed that the PowerPoint lectures would act as the guideline and structure for learning and found CODESIGN1 to be very satisfactory:

> *"I mean it's got everything we've been asking for as a class. So, for example, where there were questions in our notes we kept saying, are there answers to these questions that we could learn from. The PowerPoint would then sort of guide you in terms of the structure and the content, and then obviously you've got your PDFs and your videos to then refer to actually learn the content and then your little assessments and things."* – Evaluator 1

Overall, the evaluators were satisfied with CODESIGN1 and its ability to meet their learning needs (see Table 5-6).

5.2.4 Prototype Comparisons

The overall ranking and ratings for the prototypes are combined and presented here. A summary of the evaluator likes and dislikes of each prototype is also tabulated for comparison.

To start off, a box and whisker plot of the evaluator rankings of the prototypes are shown in Figure 5-6, where 1st rank represents most preferred and 5th rank represents least preferred.

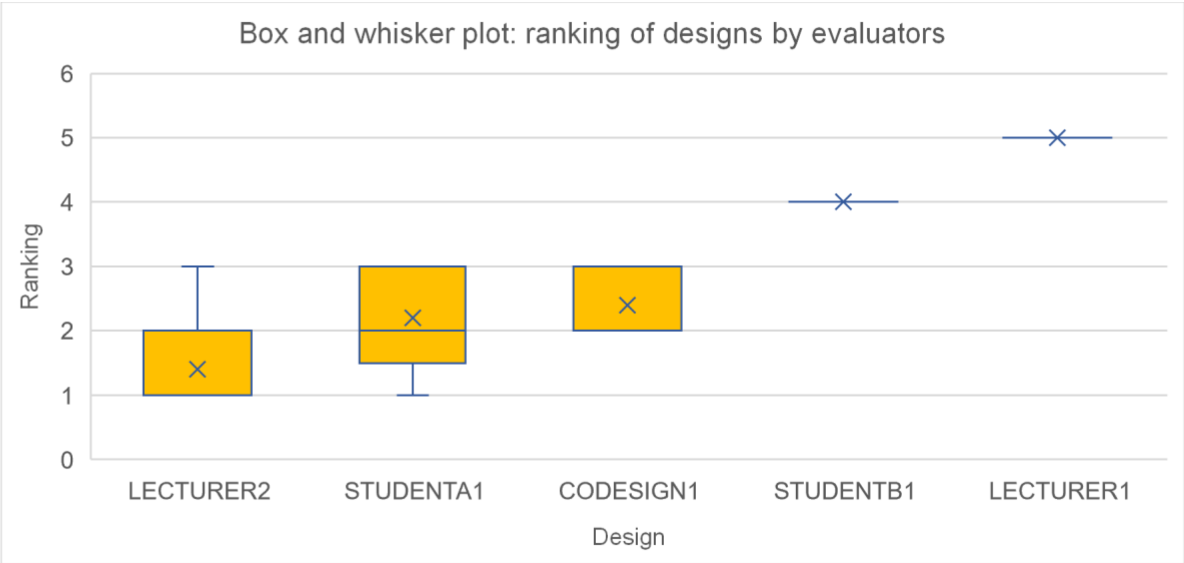

*Figure 5-6 Box and whisker plot of evaluator ranking of prototypes *(1 – Most preferred, 5 – Least preferred)*

Compare this to the evaluator ratings in Figure 5-7, where evaluators were asked to rate the prototypes based on two criteria:

1) its ability to satisfy their learning needs and
2) its ability to meet the requirements that are most important to them for online learning.

The graphs clearly illustrate that the higher ranked prototypes (top 3) were also rated higher, and the lower ranked prototypes (bottom 2) were rated lower.

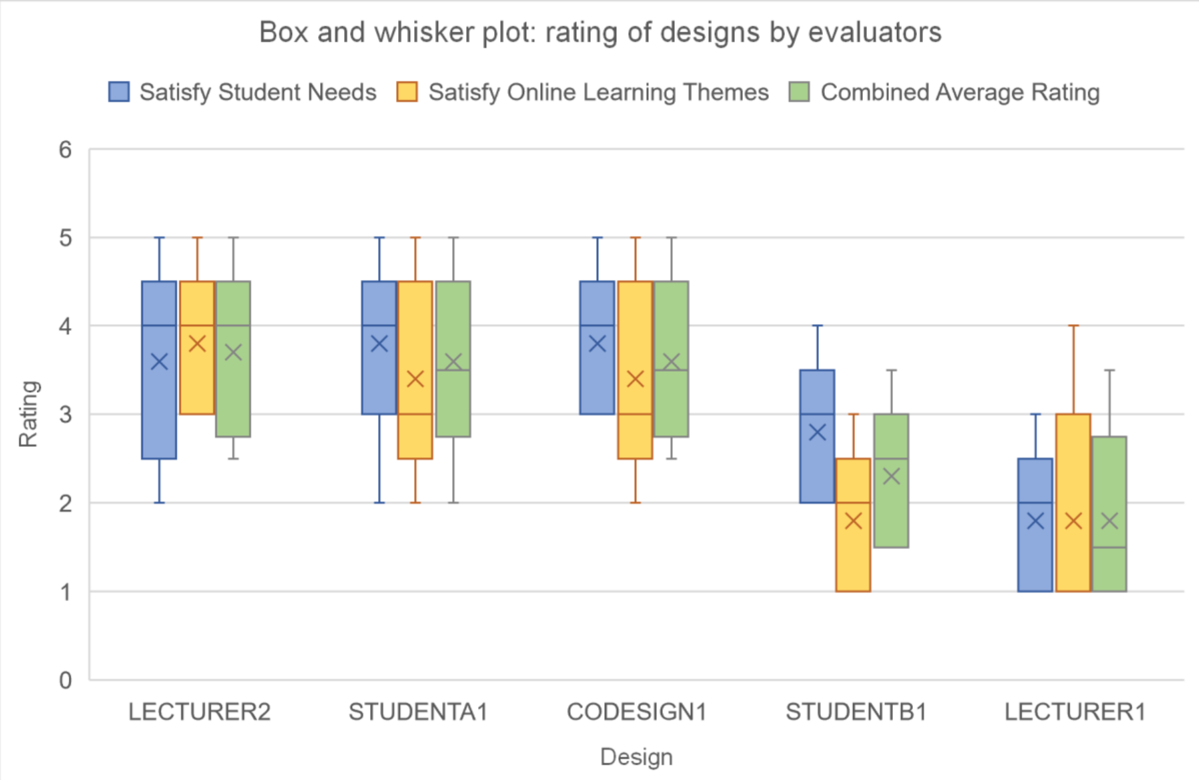

*Figure 5-7 Box and whisker plot of evaluator ratings for the prototypes *(1 – Not satisfied, 2 – Somewhat satisfied, 3 – Satisfied, 4 – Quite satisfied and 5 – Very satisfied)*

LECTURER1 (Figure 5-1) was rated lowest and ranked at the bottom consistently in terms of satisfying learning needs and requirements (see Figure 5-6 and Figure 5-7). LECTURER2 (Figure 5-4) was the top choice for 4 out of the 5 (80%) evaluators, had the highest combined average rating and considered most likely to suit their learning needs. Notably, the top and bottom designs were both designed by the lecturer. The Friedman rank test indicates that the results are statistically significant (see Appendix E).

The deciding factors for the evaluator rankings include structure (2 evaluators), interaction within the interface and its ability to engage learning (2 evaluators), satisfy requirements for online learning (1 evaluator) and available content (1 evaluator).

A summary of the elements that the evaluators deemed satisfactory and unsatisfactory for each prototype is listed in Table 5-7, listed in order of most preferred to least preferred by the evaluators.

Table 5-7 Summary of evaluator satisfactory and unsatisfactory elements of all the design prototypes

Design	Satisfactory elements / likes	Unsatisfactory elements / dislikes
LECTURER2 (Figure 5-4)	• Clear objectives • Good structure and not overwhelming • Like that it is broken down with aims, documents, videos and quizzes • Visually appealing	• No way to interact with the instructor within the interface • Nowhere to make notes • Does not guide learning in a narrative way
STUDENTA1 (Figure 5-2)	• Multiple ways to present information • Don't have to look for additional resources • Menu overview of what is available • Like that it is segmented • Easy to use	• No learning outcomes or goals that are clearly visible • No option to chat within the interface • Does not guide learning in a narrative way
CODESIGN1 (Figure 5-5)	• Lots of content to work with • Like the structure • Has a good degree of interaction (quizzes) • Like the multiple representations of data • Easy to use	• Has the fundamentals like videos and supporting materials but too much is happening • No interface to ask questions • Not a lot of instructor guidance • Goals or aims are not clearly visible • Responsibility of learning is given to the student, no guided path of where to work from
STUDENTB1 (Figure 5-3)	• Simple structure and clear flow of chapter modules • Multiple representations of content to download • Easy to get materials • Icons that identify what is what	• Too simple, too basic with only icons and no description • Does not offer feedback • No assessments or interaction • No clear goals • Looks like a repository for data files and you only download content • Does not facilitate learning
LECTURER1 (Figure 5-1)	• Having quizzes and video links available are good	• No engaging content • Does not meet the requirements for online learning • Does not attract you to read it, akin to reading a book and cannot take notes • The content is there but you don't know when the quizzes and videos links will appear – you have to look for them • No additional learning materials that are clearly visible

LECTURER2 was ranked first due to its structure and contents (e.g. broken down with aims, documents, videos and quizzes; see Table 5-7). Most of the evaluators (4 evaluators) preferred this design and felt that it would satisfy their learning needs, with one evaluator very adamant on it:

> *"LECTURER2 is for sure number one. It had aims, quite a lot of interactions and videos." – Evaluator 4*

Two evaluators felt that LECTURER2 was most satisfactory as it provided clear goals for the chapter and was visually appealing. One evaluator was rather satisfied with this design but suggested that if they combined elements of CODESIGN1 or STUDENTA1 with LECTURER2 then "that would be perfect".

STUDENTA1 and CODESIGN1 were considered similar and three evaluators would rank it the same. However, when pushed for a ranking, STUDENTA1 came out on top because it was not "overwhelming" and well organized (also see Table 5-7). CODESIGN1 was too compact and clustered with the materials next to each other, and the evaluators did not see the point of this. This compactness also resulted in the material embedded to be smaller, which the evaluators did not like.

STUDENTB1 ranked second last as it didn't satisfy most learning requirements but was considered better than LECTURER1, as it did have structure and multiple representations of content. The evaluators considered LECTURER1 "basically what is given in the course now" and all the evaluators ranked it last.

Overall, the evaluators felt that all the prototypes were unable to guide the learning process. Even though the evaluators expressed that they liked that there was generally structure to the designs, it could have improved in its ability to facilitate and guide learning. For example, one evaluator expressed for LECTURER2:

> *"I like that there are videos and quizzes on this interface, but I would have preferred that there is a quiz after a video instead of just quizzes for the chapter. Even if the quizzes were intended for each video, it is not so obvious to me on the interface." – Evaluator 4*

The prototypes met their expectations for multiple representations of content and partially satisfied their navigation needs (see Table 5-7). Some prototypes offered active learning opportunities (LECTURER2, STUDENTA1 and CODESIGN1), only one prototype included goals and expectations (LECTURER2) but most prototypes failed to meet interaction and feedback requirements (LECTURER1, STUDENTB1 and LECTURER2).

5.2.5 Observations

On the presentation of the first prototype design, all the participants spent a lot of time analysing the design before going on to answer the interview questions. When the participants reached the third prototype design, the time spent analysing the design visibly decreased and the process of evaluation became much faster. For designs with fewer elements, most participants would make a remark such as "so it's just a PDF" to make sure that they understood the design.

It was quite clear which designs the participants preferred and disliked based on the remarks that they made during the process of exploring the prototype designs. Some participants were quite outright, repeating their reaction towards the design upon seeing it, such as "Oh no, I don't like this one, I don't like this one". Other participants preferred to internalise the design before expressing their thoughts. There were much stronger reactions from the participants towards their unfavoured designs as opposed to the ones they did favour.

Order bias was accounted for in the study and it seemed like it was rather important to do so. Since the evaluators did not know what kind of designs to expect, on presentation of the first design, they would anticipate what the other designs were like. As an example, every evaluator from the second design onwards would compare it to the previous design that they explored.

It was interesting to see how the assumptions made by the evaluators affected their ratings. One of the biggest observations is regarding the PowerPoints included in some of the designs. For some evaluators, including a PowerPoint was an advantage because they automatically assumed that these PowerPoints would provide a summary of the most important materials to learn by the lecturer. To them, this was their guide to learning and would also be their starting point when learning for the course. This is interesting because that was the initial purpose for the designers to include PowerPoints.

For other evaluators, this was just considered another representation of the content and their rating for the design just depended on which media form they preferred.

5.3 Discussion for Prototype Evaluations

5.3.1 Design Approaches and Its Influence on Student Satisfaction

The combination of findings from Chapter 4 and the outcomes from this chapter show that the design in consultation approach produced the most satisfactory prototype for students. LECTURER2, which was designed by the lecturer through a design in consultation approach, ranked first amongst the prototypes (see section 5.2.4). Although the prototype met online learning requirements that were important to the students, it is worth mentioning that the evaluators found the prototype more visually appealing, which influenced their ranking (see section 5.2.2 iii and 5.2.4). Kurosu & Kashimura (1995) suggests that the aesthetic aspect of an interface may strongly affect the user, which is something to consider in this case.

It is important to compare this prototype to LECTURER1, which was produced via teacher design and ranked in last place. As mentioned in the Chapter 4 findings, the lecturer prototypes from teacher design and design in consultation would not have been different if the discussions amongst the co-design team had not taken place (see section 4.2.2 iii). This suggests that the process of idea sharing in co-design and divergent thinking as a group influenced the design and evaluative outcomes in this case. This supports the work of Warr & O'Neill (2005), where they argue that designers sharing ideas is better for creativity than designers working alone.

While STUDENTA1 and STUDENTB1 were also produced via the design in consultation approach, it was ranked in second and fourth place by the students respectively (see section 5.2.4). A possible explanation for this is that the lecturer possesses pedagogical knowledge and course design experience which the students do not have. This implies that while students are experts in their own ways of learning, they lack knowledge of pedagogical practices that aid in design for education. This emphasizes the importance of teacher expertise in pedagogy, teaching and course design. By combining teacher expertise with idea sharing in co-design, the lecturer was able to shift from focusing on content issues to prioritising content delivery on the interface.

The mutually produced prototype, CODESIGN1, only managed to secure a middle ranking (see section 5.2.4). In this case, the evaluations suggest that co-designed artefacts do not necessary produce the most satisfactory outcome for the stakeholders. Comparing this to evaluations of LECTURER2, it could imply that divergent thinking as a group can have a better impact on user satisfaction than convergent thinking as a group in some cases. This could explain why divergent thinking, which is about idea generation, is often associated with creativity in design, as opposed to convergent thinking, which involves selecting the presumed best idea (Frich et al., 2019). What this means for design is that sharing of design ideas (divergent) could be more important and impactful than shared design activities (convergent).

5.3.2 Limitations and Difficulties of Effective Multi-Stakeholder Co-Design for Online Learning

Although the co-design session produced more satisfactory designs for the students, it still did not completely satisfy their needs and all the prototypes failed to guide the learning process (see section 5.2.4). The co-designed prototype, where full participation in design should have been achieved, did not manage to come out on top. It may be that the mutually produced design was “chosen” rather than designed (see section 4.2.3 i).

This is in line with the study done by (Trischler et al., 2018), where they found that co-design can but does not always lead to the most innovative outcomes. In fact, they found that co-design can sometimes diminish these outcomes. This may be due to the team diversity, familiarity and various factors that may be in play during co-design and the phenomena which can occur due to these factors.

i. Familiarity Between Team Members

The familiarity between the co-design team members may have hindered the outcomes of the design. As it was the first time this co-design team collaborated, there was no familiarity between them. Depending on the design cohort and their individual personalities, a designer may not be as comfortable to express their true opinions in an unfamiliar team. Team bonding is an important factor for co-design, as this allows team members to have a good degree of familiarity with each other to contribute actively during the design process (Trischler et al., 2017).

ii. Motivation of Designers

The motivation of different team members may also contribute to effectiveness of co-design. Users may not think outside of their current needs, which may lead to outcomes that do not support the broader user base (Trischler et al., 2017). If such users dominate the co-design process, it could lead to the co-designed product not satisfying the broader market needs. This suggests that users, along with their motivations, should be carefully selected for co-design activities (Trischler et al., 2017).

iii. Design Environment and Conditions

The full benefits of co-design may not have been reached in this process and may only be realizable under certain conditions (Trischler et al., 2017). Not setting the right conditions for team bonding and collaboration may hinder the co-design outcomes. This is because co-design activities are usually short in duration and would often involve individuals who have not previously collaborated (Visser et al., 2005). This was the case of the co-design session in this study. The lack of experience from the facilitator, the co-design environment and the unstable audio and visuals during the session may have influenced the outcomes.

iv. Iterations

This complexity of team dynamics and process facilitation indicates that successful co-design is not just a simple matter of actively involving users in the design process. Several factors may influence the co-design outcomes and should these factors not be well considered, co-design may not be any more beneficial than individual design. However, when we compare LECTURER1 and LECTURER2 evaluations, LECTURER2 is significantly better received than LECTURER1. This either implies that iterations can significantly improve outcomes or the discussions that took place during the co-design session influenced the lecturer's prototype.

v. Design-Reality Gap

Lastly, the gap between design and reality is ever present. From the evaluations, it is evident that one or more of the designed prototypes do not meet the expectations of some of the student stakeholders. This is defined as expectation failure, where the designed system is unable to meet a stakeholder group's expectations (Lyytinen, 1988). These design-reality gaps can occur as a result of several dynamic processes, where factors such as designers are not being fully informed of the problem and technology is not available for optimal design are realities.

From the design process, it is also clear that there exists a gap between the co-design concept in theory and co-design in practice. The reality is that people are at the core of design, which has a huge impact on the co-design dynamics. Each individual varies in the way they process information, arrive at decisions and work together in a team. All these factors act dynamically and influence the outcome. As a result of this design-reality gap, the full benefits of co-design are not always reached.

5.3.3 Interpretation Differences in Translating Concepts to Design

All the evaluators expressed in some way that the designs mostly satisfied the need for multiple representations of content but failed to guide the student to learn from the interface in a narrative way (see section 5.2.4). It was important to the evaluators that the interface was able to guide the student and show a pathway to learning via the interface rather than use the interface as a "repository for data files".

This is an interesting result because during the co-design session, there was a lengthy discussion of the importance of a pathway to learning. However, this did not seem to translate through to any of the designs. This implies that while users may know what they want conceptually, they do not necessarily know how to express this in their design. Perhaps, rather than saying "not knowing", the concept of a pathway to learning was understood differently. The designers considered a pathway to learning in practice, where the pathway is formed via stepping through small assessments to go on to bulkier assignments. The evaluators on the other hand, did not only find this important but were also looking for a pathway on the interface that would guide their learning process.

6 Conclusions and Future Works

This study stands as both an examination of alignment between expressed student priorities, current online learning knowledge and actual online course practices, and as a comparison of the phenomena that occurs with different design approaches and its effect on design output and student satisfaction. It also gives insight to the limitations and difficulties of effective multi-stakeholder co-design for online learning.

While expressed student learning needs generally aligned with online learning in literature, actual online course practices presented a design-reality gap. This study expanded on the current online learning literature and took a more in-depth look into student learning needs in the case of MIT. Themes like clear navigation and guidance, multiple representations of content, active and progressive learning, individualized and timely feedback, foster interactions via asynchronous and synchronous tools and consistency and managing expectations generally aligned with current knowledge for online learning design. As students are increasingly exposed to technology around them, their learning needs resemble this influence and have more need for content delivery that is multi-faceted and have multiple modalities.

However, actual online course practices may have not yet reached this level of technology usage, as shown in the context of the MIT course in this study. There could be several causes of this: lecturers may not be informed of actual student needs, or aware of tools available to them to create a satisfactory course; there may be a lack of resources and skills for optimal design work; or just reluctance of staff to adopt new practices. These informational, technological and institutional causes interact dynamically to produce both the gap between literature and practice, as well as design and reality.

A comparison of design approaches revealed that deviation from student priorities emerge at the beginning stages of the design process. The way each individual processes information and their internal divergent and convergent thinking processes result in deviations from student priorities. Deviation from student priorities also emerge when individuals interpret concepts differently in their design output. Sharing of design ideas in the co-design process can alleviate these deviations, as the individuals receive input from external sources, broadening their perspectives and getting introduced to new ideas. Co-design activities on the other hand, can sometimes diminish creativity when convergent thinking as a group determines the design output, as illustrated in the co-design process of this study. The dynamics of these thinking processes directly influences the outcome of the produced artefacts and user satisfaction.

The evaluation process revealed that the metrics used by the students to evaluate the prototypes largely aligned with their expressed priorities in the requirement elicitation interviews. Students were most satisfied with the design output by the lecturer via the design in consultation approach, showing the importance of generating ideas through shared knowledge, as well as the importance of the educator's pedagogical knowledge and design experience. It also illustrates the ability of co-design to produce better outcomes of user satisfaction, and without the need of maximum user participation – as indicated by the average ranking of the mutually produced design approach. However, the participation of students in design still did not produce a prototype that fully satisfied student priorities, in that all the prototypes did not meet the criteria to clearly guide and facilitate the learning process.

There are many factors that limit effective multi-stakeholder co-design in the online learning space. These include degree of familiarity between co-design team members, motivation of individuals, design environment and conditions and the number of design iterations. The design-reality gap is also an ever-influencing factor. The gap between co-design in literature and in practice also varies with individuals, the way they process information, arrive at decisions and work together in a team. The full benefits of co-design may not always be realized due to these factors acting together dynamically in reality.

Overall, the success of the design approach is dependent on many factors, from the ability of the designers to the execution of the design process, as well as the reality in which it exists. From the findings of this study, two recommendations are suggested for future online course design in MIT and similar settings:

- Conduct a short session (an hour) with two or three students who have taken a module in the course where the lecturer and students share their experiences and design ideas for their ideal module, instead of or in addition to course evaluations.
- Carve out or make use of a course designer role to make improvements to the course as lecturers may be time constrained.

This study is an initial step towards understanding alignment between design approaches and student priorities for online learning platforms. With the dynamic influence of various factors affecting co-design, more work exploring these factors and quantizing them can be part of future works. Future research should also work towards exploring ways to gain mainstream adoption of design approaches that can bridge the design-reality gap in the online learning space, such as co-design.

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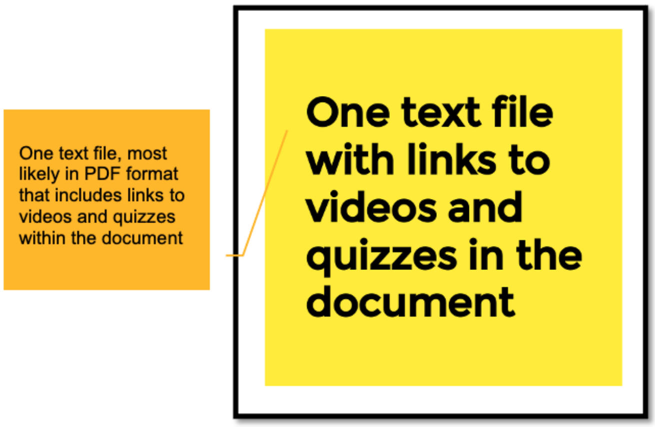
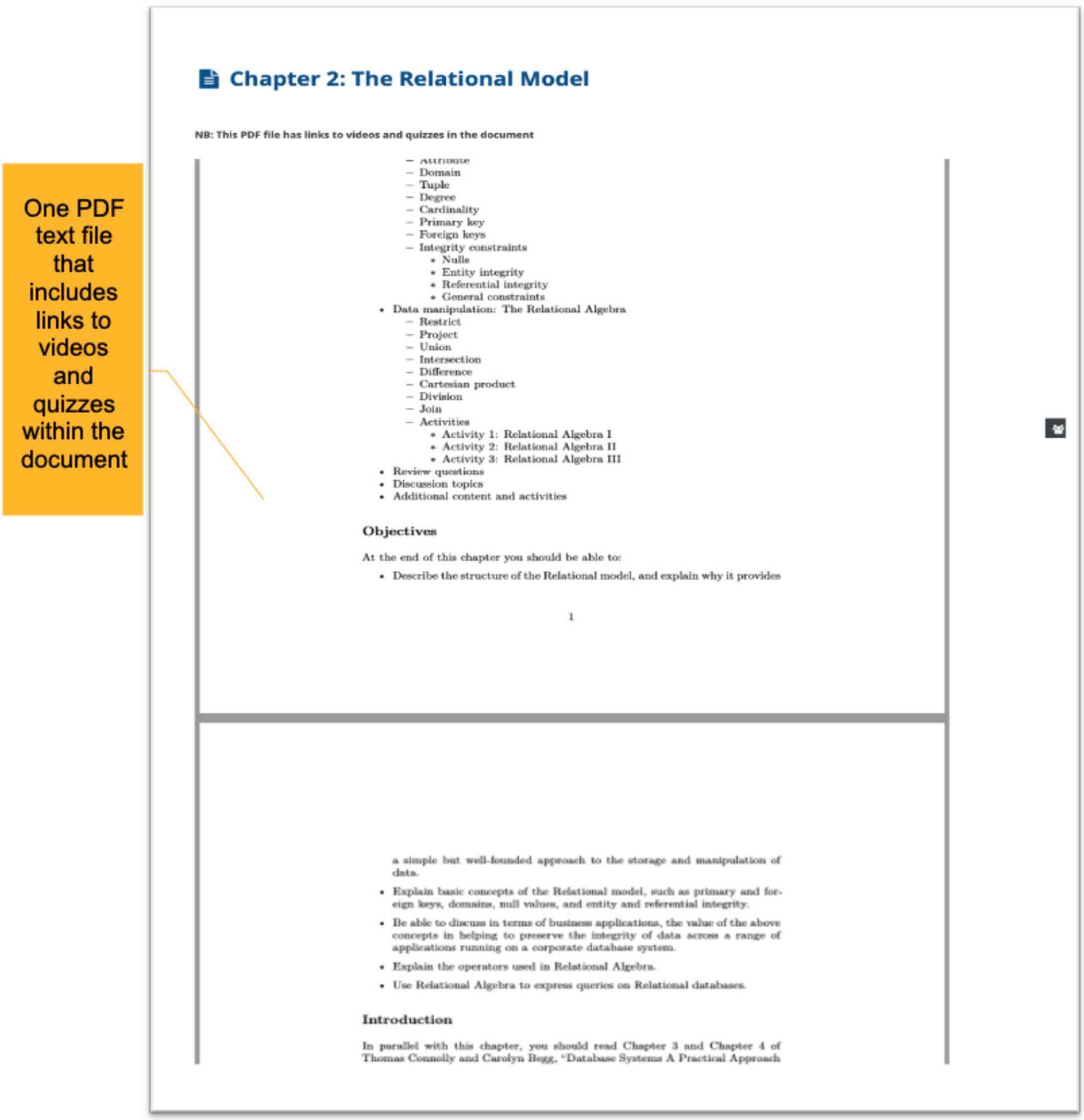
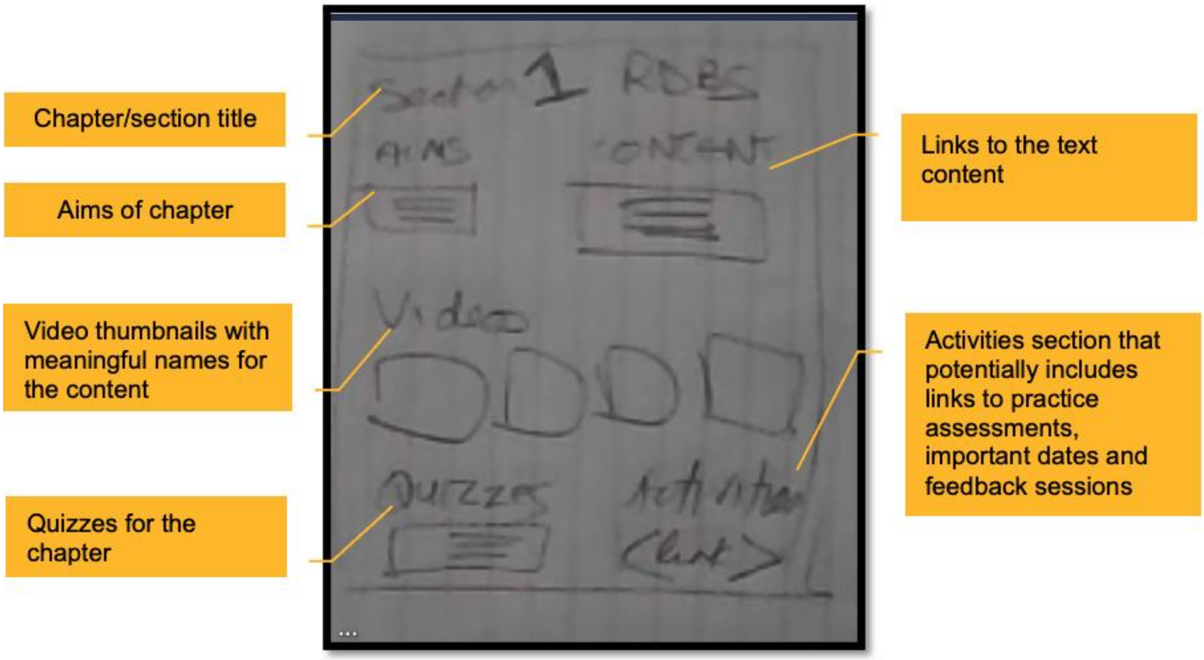
Appendix A

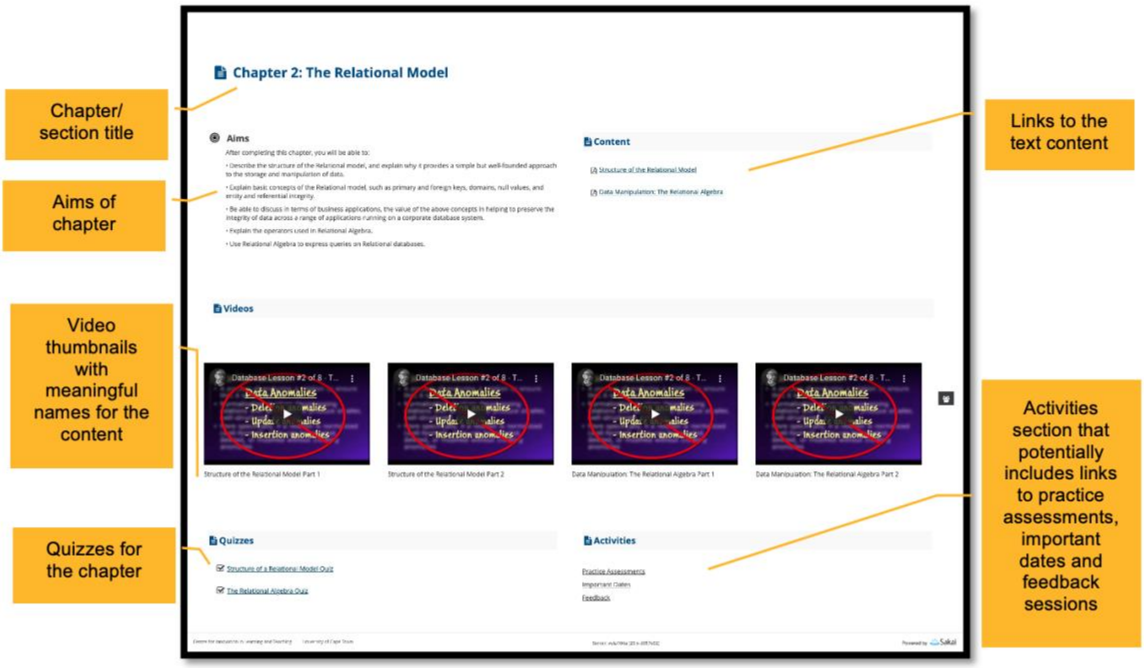
A.1 Sketch to Prototype – Lecturer (Individual Session)



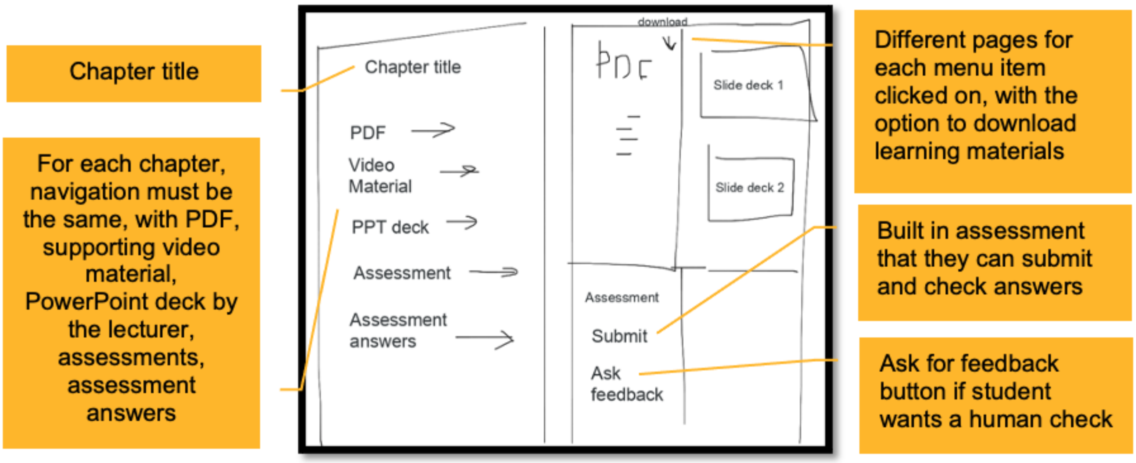


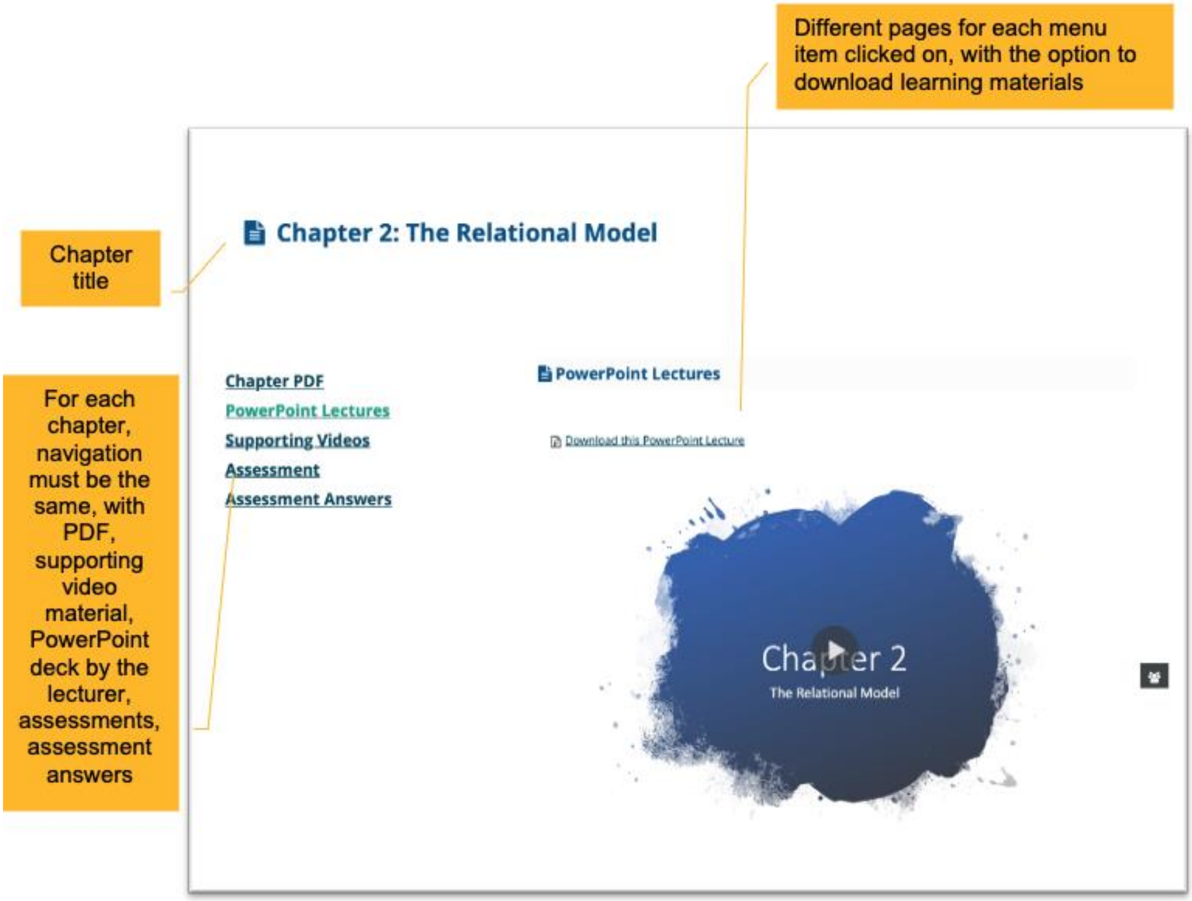
A.2 Sketch to Prototype – Lecturer (Co-design Session)

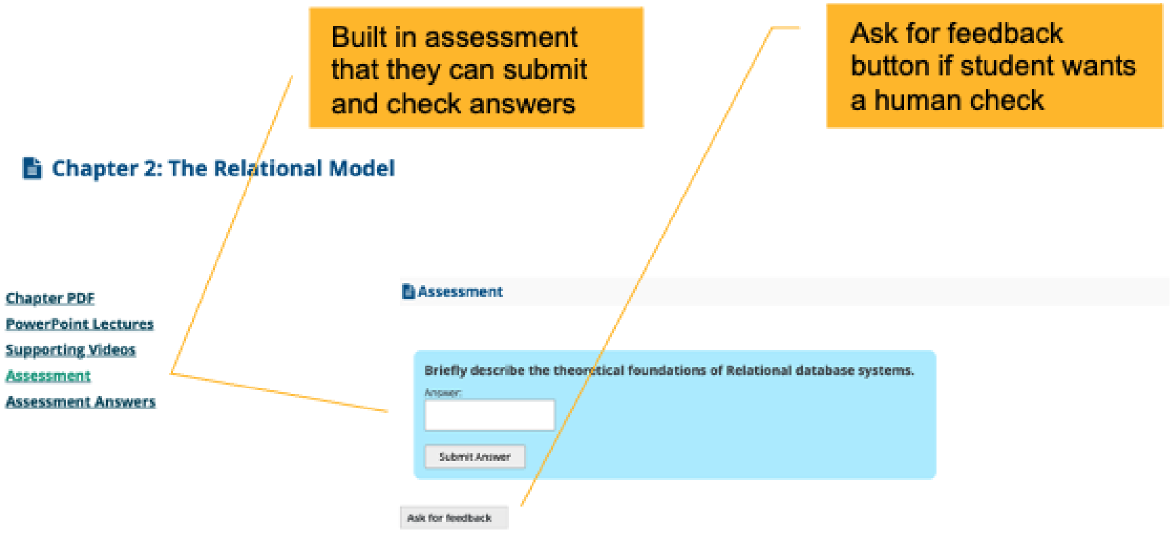




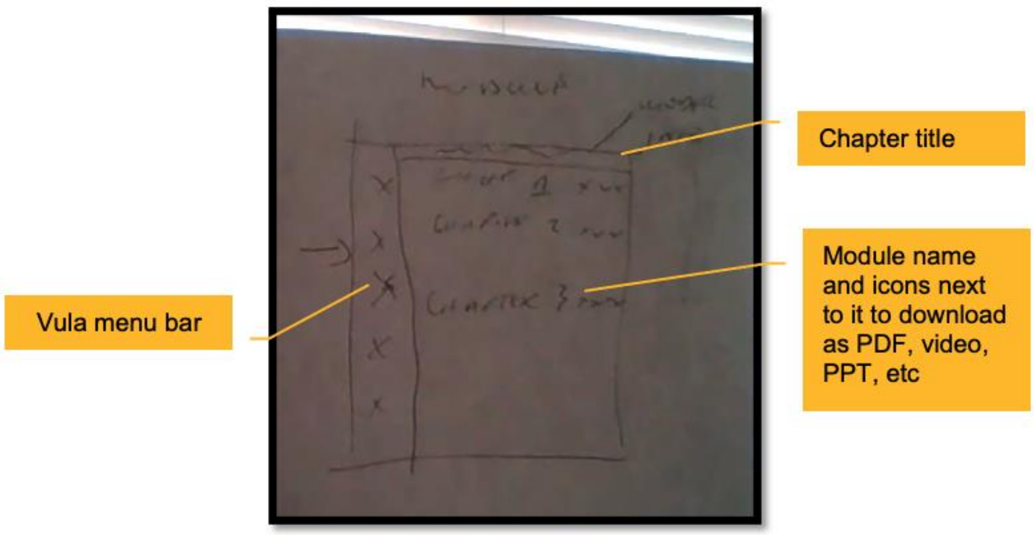
A.3 Sketch to Prototype – Student A

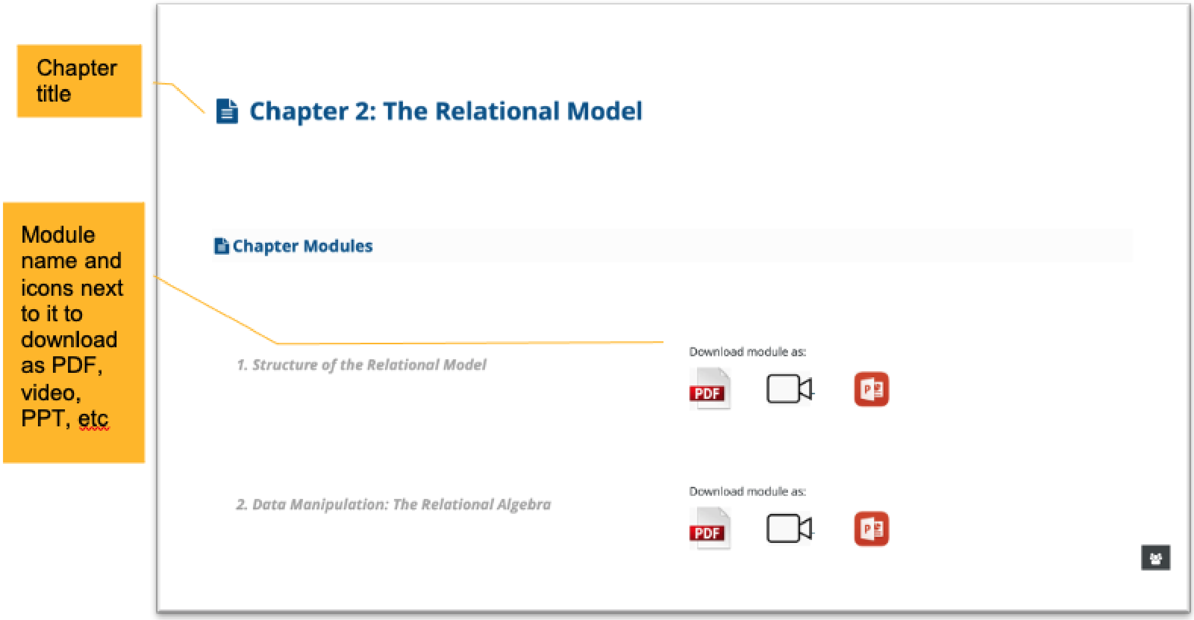




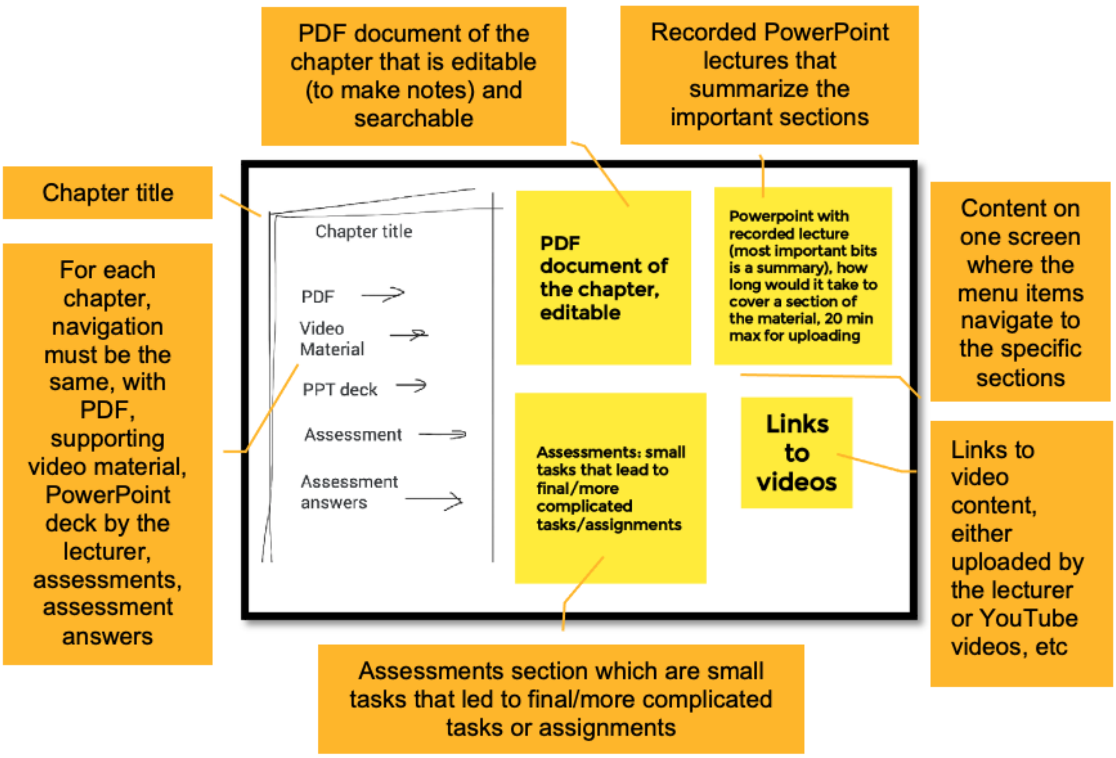


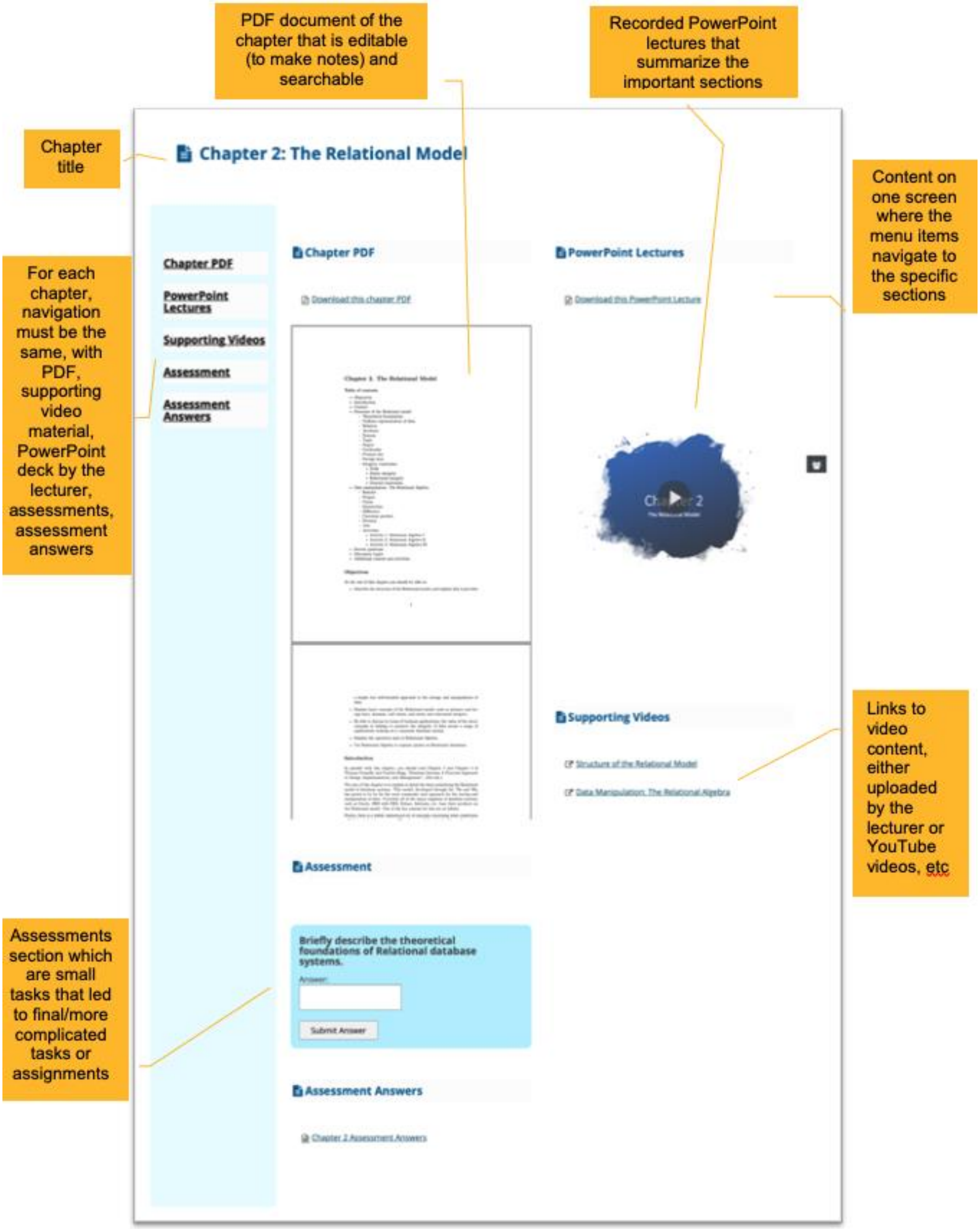
A.4 Sketch to Prototype – Student B





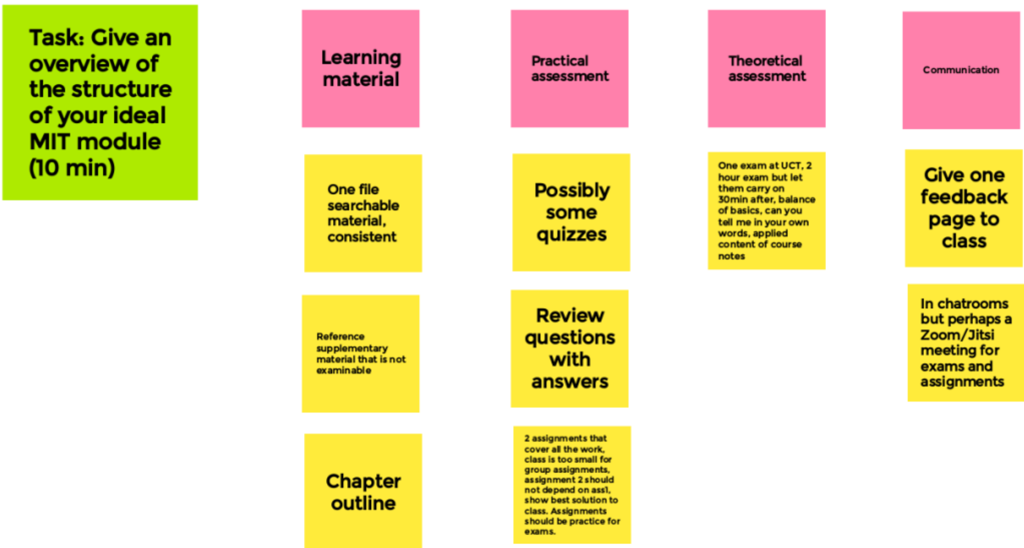
A.5 Sketch to Prototype – Codesign Team




PDF document of the chapter that is editable (to make notes) and searchable
Recorded PowerPoint lectures that summarize the important sections
Chapter title
Chapter 2: The Relational Model
Content on one screen where the menu items navigate to the specific sections
For each chapter, navigation must be the same, with PDF, supporting video material, PowerPoint deck by the lecturer, assessments, assessment answers
Chapter PDF
PowerPoint Lectures
Supporting Videos
Assessment
Assessment Answers
Chapter PDF
PowerPoint Lectures
Supporting Videos
Links to video content, either uploaded by the lecturer or YouTube videos, etc
Assessment
Briefly describe the theoretical foundations of Relational database systems.
Submit Answer
Assessments section which are small tasks that led to final/more complicated tasks or assignments
Assessment Answers

Appendix B

B.1 Idea Board – Lecturer (Individual Session)



B.2 Idea Board – Lecturer (Co-design Session)

Response to findings: Analyze - What are the important features of a successful MIT Database course? (2 min)

videos

occasional teams/zoom meetings

cameraderie & sharing/communication

easier navigation

frequent rapid feedback

Give an overview of the structure of your ideal MIT module. What should it consist of? (e.g. no. of assignments, type of communication, etc) (10 min)

Learning material

1 PDF per section (with a few related chapters in it) and each section & chapter starts with outline & objectives/outcomes

PDF notes possibly include links to Vula forum, Vula quiz and Vula online videos at appropriate places

Practical assessment

Assignments remain individual as the class is small and there is only time for 2 assignments. They should preferably be application of knowledge

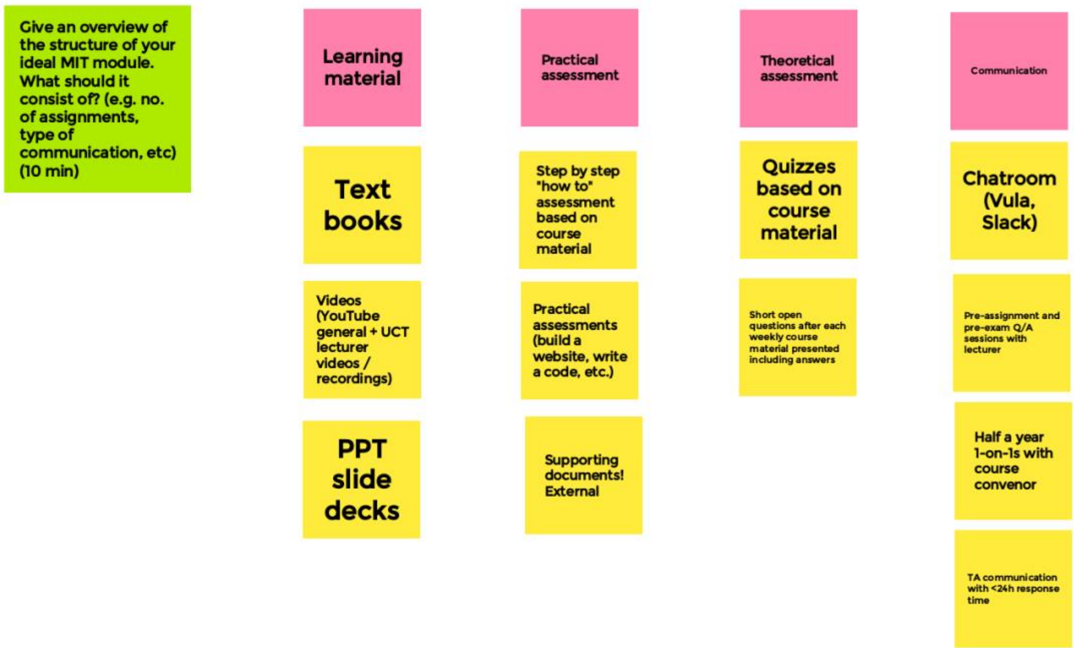
Theoretical assessment

Exams should be on campus, as is now. Include handouts of what isn't necessary to memorise eg SQL cheat sheet.

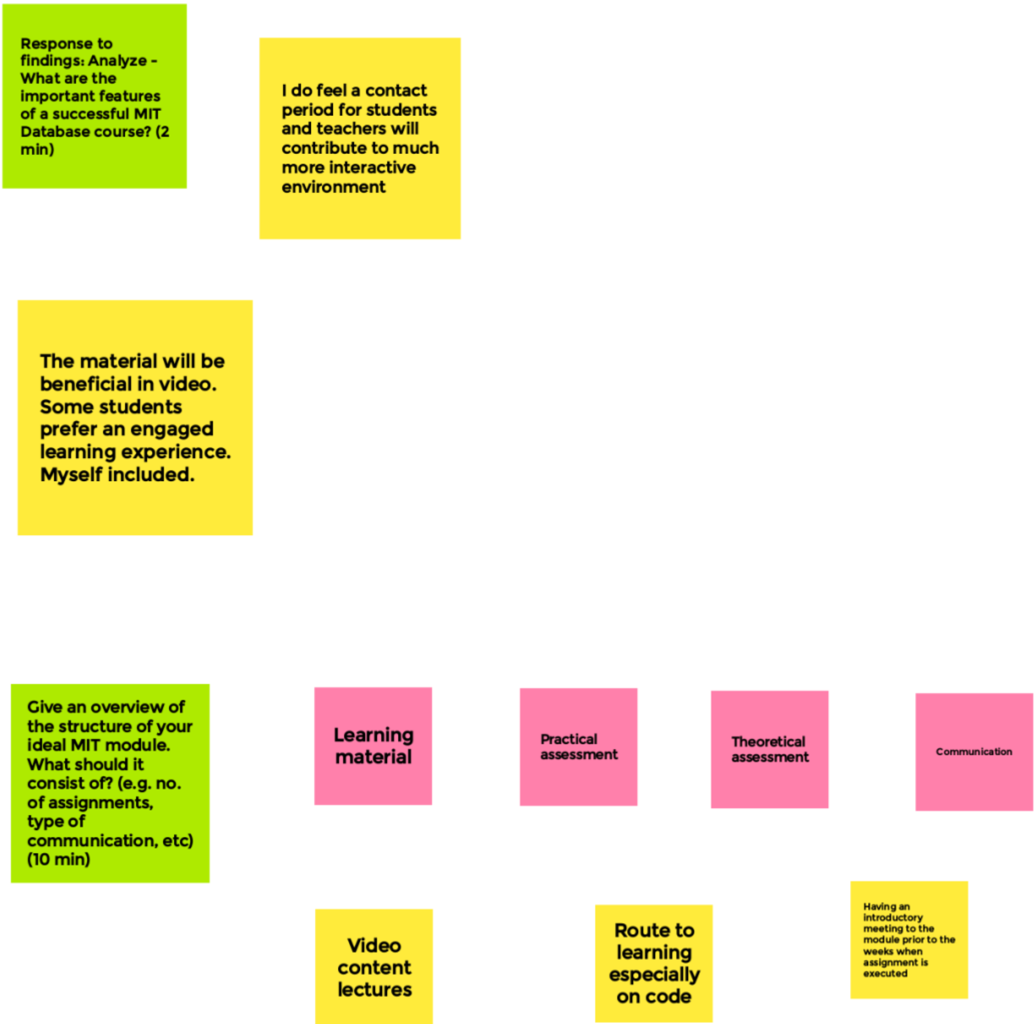
Communication

I prefer Vula forums for most communication so everything is in one place, and for each assignment & for the the exam also a Vula chat session and/or an online zoom/teams session

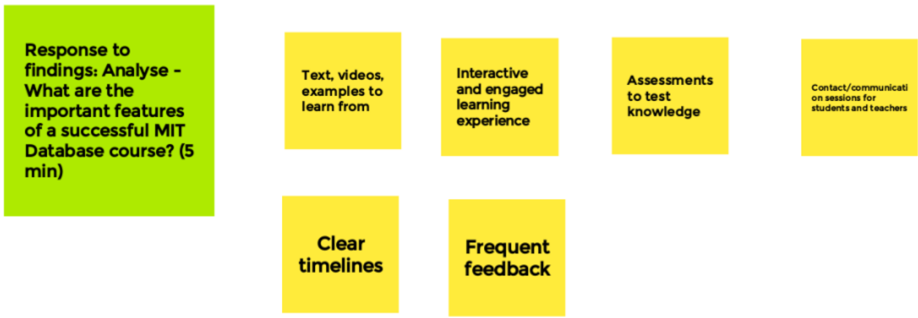
B.3 Idea Board – Student A

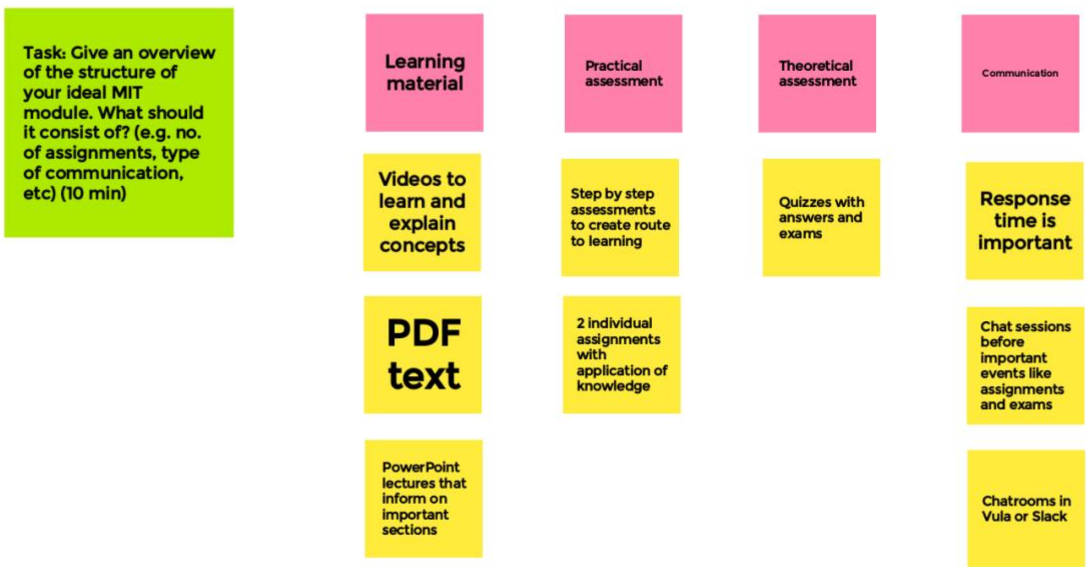


B.4 Idea Board – Student B



B.5 Idea Board – Co-design Team





Appendix C

C.1 Individual Session PowerPoint Presentation Guide

Individual Design Session

Pre-design questions (8 min)

Lecturer

1. What would you change about the current course/module?
2. What would you change about the current lesson plan (the way the materials are presented to the students)?
3. What do you think the students want improved in the course?
4. What challenges do you face when wanting to change the module?

Overview of research (1 min)

- 22 interviews conducted with current MIT students
- Share results with designers
- Objective: to explore different approaches to design of MIT coursework
- Design output: sketches of an example lesson. How do students want the material presented?

Current course design (2 min)

- All course materials are accessed via Vula
- Course timelines are provided before the start of the course, with assignment due dates and examination dates
- Course materials are all provided at the start of the course after enrolment
- Each module's content, assignments and examinations are set by the respective lecturer, including course content delivery medium
- Teaching assistants are assigned to each module
- Predominantly delivered via text, in the form of PDF documents
- Two individual assignments and an examination for each module
- Teaching assistants/lecturers mark the assignments, usually feedback is provided on rubric/separate sheet
- Auto-marker used for coding assignments
- An introductory session is held at the start of the course for all MIT students
- Designed for desktop/laptop

Current course implementation/glitches experienced (2 min)

- Limited use of Vula platforms features
- Usually chapters are PDFs placed in the resources folder on Vula
- Sometimes not clear to the students' which resources are part of the course and which are additional resources
- A few cases where the material examined or in the given assignments did not match the course material provided for learning
- Some assignments were not released on time
- Some assignment due dates differed from the course outline provided at the beginning of the course
- Some modules have review questions at the end of the chapters in PDF, some with answers and some without
- No group assignments and interactions are predominantly with the lecturer or teaching assistant
- Even though students are encouraged to interact with each other, and the course has an introductory session, interaction still seems to be lacking. Perhaps missing rapport

Student expectations (5 min)

Theme	Student expectations
Goals and expectations	• Assessments and exams should align with learning objectives and course content • Student expectations could be set by giving timeframes, whether it is assessment deadlines or response time from lecturers/TAs
Multiple representation of course content	• Students perceive short videos as the best mode of content delivery, with ability to change speed • Students still find that text is important and cannot be done without, whether in long text like PDF or summary form like PowerPoint • Students prefer to grasp a concept visually via video but still need text as an anchor and incite further understanding
Assessment of learning/active learning	• Students would like additional optional assessments with answers to test knowledge • Interactive interface to host optional assessments and knowledge checkpoints • Purpose: benchmark their acquired knowledge and keep track of where they are in the course

Student expectations

Theme	Student expectations
Feedback	• Inline commentary on assignments • Understand their weaknesses from the feedback • Direction to course material that will help them improve on these weaknesses
Flexibility and choice	• Course materials should be made available upfront so that they could take the course at their own pace
Interactions	• Consider how to foster interactions within online courses, and build rapport amongst peers and teachers alike • Quite a few students thought that collaborating with their peers is rather valuable • Students desired frequent communication with teaching staff and advocated strongly for active involvement from both ends

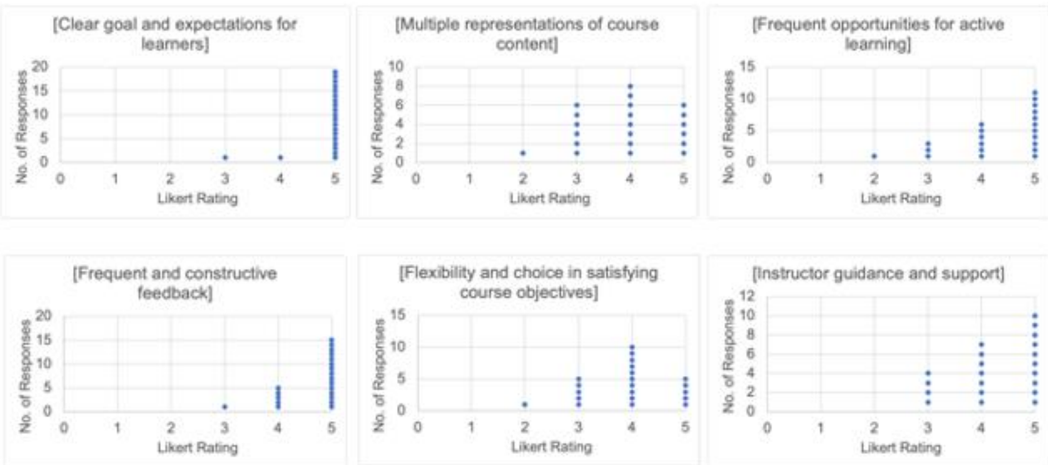
Student expectations

Theme	Student expectations
Tools	• Tools like Slack, Microsoft Teams and Zoom came up often as an example of the type of interactive platform that the respondents would like. • The functions that the respondents found useful on these platforms include sharing screens, adjustable microphone and video, push notifications, organize per subject or course, tag people, add attachments, see who has joined, type chat, videos, conferences and keep track of all the people who "raised their hands".
Navigation	• Students desired online learning platforms that have a clear and simple navigation structure, intuitive navigation • They wanted a platform that does not use up their resources, i.e. does not take up a lot of time to get familiar with and should not have to consult outside resources.
Platform	• Inline commentary on assignments • Understand their weaknesses from the feedback • Direction to course material that will help them improve on these weaknesses

Importance Rating (1 min)

Category	Importance Rating (Mean)	Importance Rating (Mode)	Importance Rating (Median)
Clear goals and expectations for learners	4.86 ± 0.48	5	5
Multiple representations of course content	3.90 ± 0.89	4	4
Frequent opportunities for active learning	4.29 ± 0.90	5	5
Frequent and constructive feedback	4.67 ± 0.58	5	5
Flexibility and choice in satisfying course objectives	3.90 ± 0.83	4	4
Instructor guidance and support	4.29 ± 0.78	5	4
Frequent testing of knowledge (e.g. quizzes, self-assessments, etc)	4.38 ± 0.97	5	5

Importance Rating (1 min)



Design Session (30 min)

Three sections/tasks

1. Response to findings: Analyze what are the important features of a successful MIT Database course? (5 min)
2. Give an overview of the structure of your ideal MIT module. What should it consist of? (e.g. no. of assignments, type of communication, etc) (10 min)
3. Sketch out 2 possible layouts on how you would like this material to be presented to the students using Databases as example material (10 min)

Individual design link:
https://jamboard.google.com/d/1Frw8O0sgofMPuxcLBoDS2Iwa9AW09Cne09oLOAGBUME/viewer?f=0

Post design questions (5 min)

Lecturer

- What challenges do you face when implementing these changes?
- Were the student requirements as you expected? If no, what was different?

C.1 Co-design Session PowerPoint Presentation Guide

Codesign Session

Introductions (4 min)

Overview of research (1 min)

- 22 interviews conducted with current MIT students
- Share results with designers
- Objective: to explore different approaches to design of MIT coursework
- Design output: sketches of an example lesson. How do students want the material presented?

Current course design (3 min)

- All course materials are accessed via Vula
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Current course implementation/glitches experienced (3 min)

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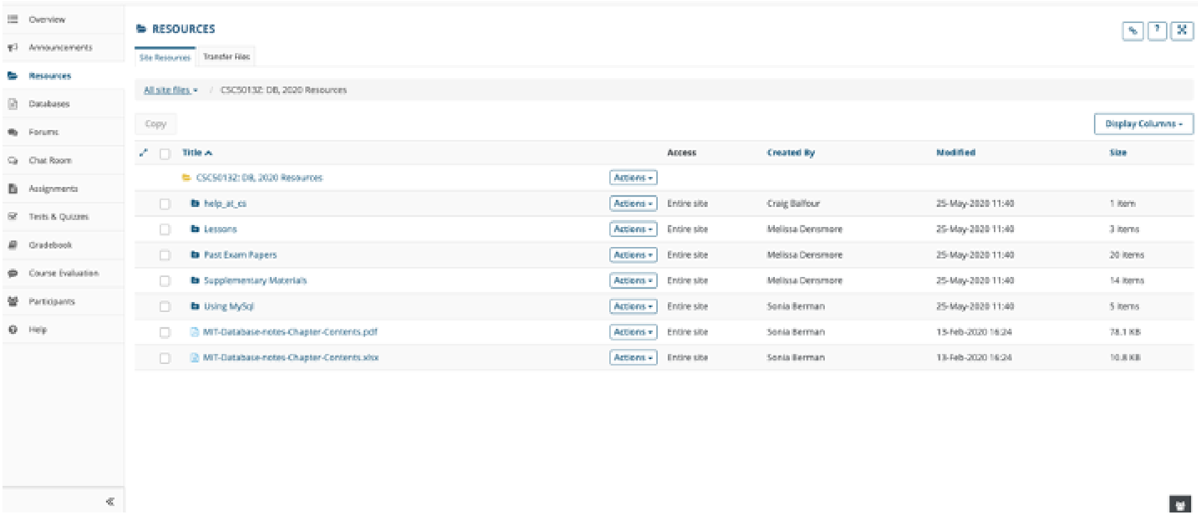
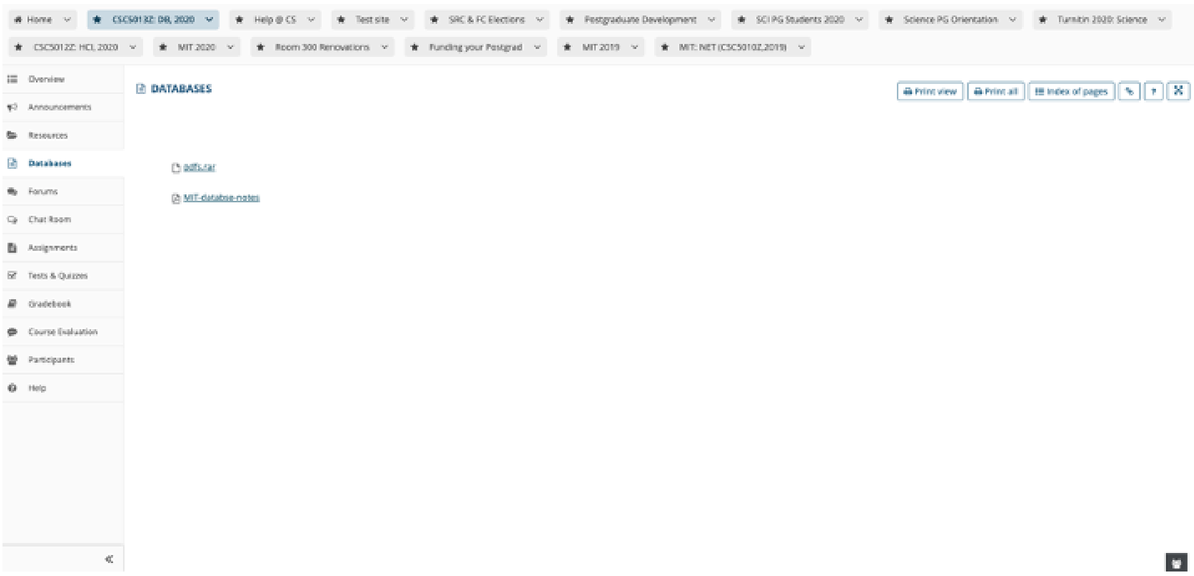
Example



Example



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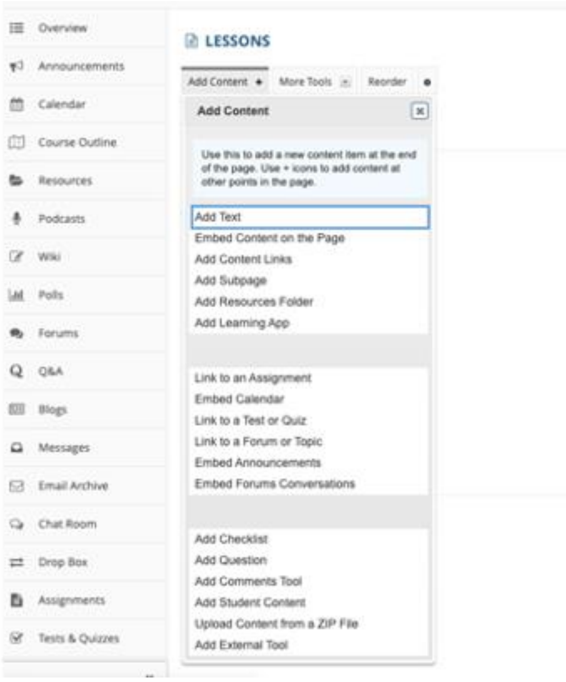

Student expectations/feedback (8 min)

Theme	Student expectations
Goals and expectations	• Assessments and exams should align with learning objectives and course content • Student expectations could be set by giving timeframes, whether it is assessment deadlines or response time from lecturers/TAs
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Navigation	• Students desired online learning platforms that have a clear and simple navigation structure, intuitive navigation • They wanted a platform that does not use up their resources, i.e. does not take up a lot of time to get familiar with and should not have to consult outside resources.
Platform	• Desktop/laptop • Communications also accessible via mobile

Rating by students of themes (1 min)

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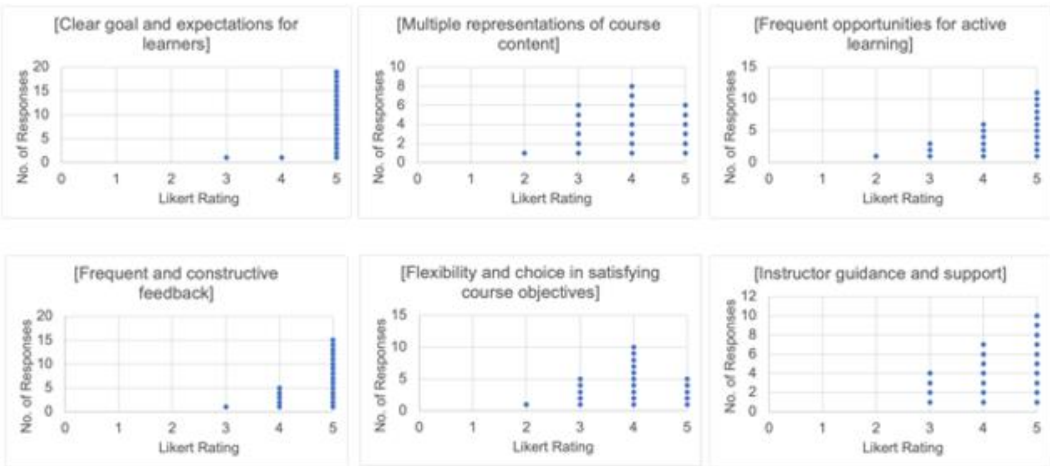
Rating by students of themes (1 min)

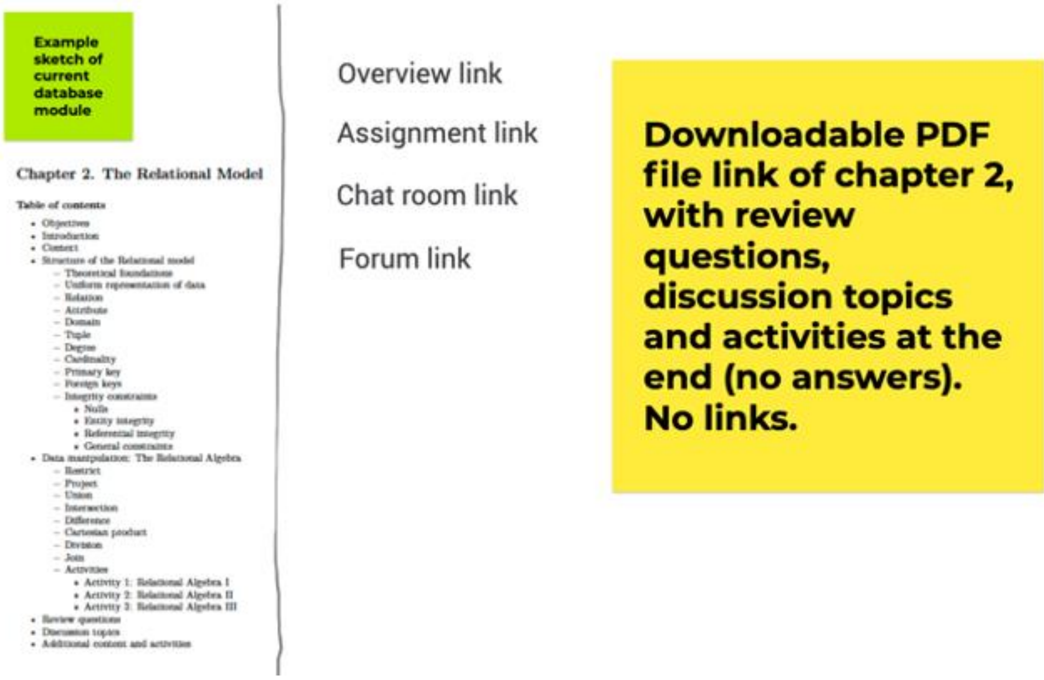


Design Session (30 min)

Three sections/tasks

1. Response to findings: Analyze - What are the important features of a successful MIT Database course? (5 min)
2. Give an overview of the structure of your ideal MIT module. What should it consist of? (e.g. no. of assignments, type of communication, etc) (10 min)
3. Individually sketch out 2 possible visions on how you would like this material to be presented to the students using Crazy 8 method (5 min)
4. Sketch out 2 possible visions on how you would like this material to be presented to the students using Databases as example material (10 min)

Crazy 8 sketching example



Post design questions (5 min)

All

- What challenges do you think the lecturer faces when implementing these changes?
- What solutions can you think of to address these challenges?
- Were the student requirements as you expected? If no, what was different?

Appendix D

D.1 Evaluation Interview Questions

Questions on each design

This design is a representation of a lesson in Vula. Consider if the whole course was presented to you like this, how do you see yourself studying for the course (usually, preparing for assignments and exams, etc)?

Answer:

Submit Answer

How would you rate this design in terms of satisfying your learning needs?

- 1 : Not satisfied
- 2 : Somewhat satisfied
- 3 : Satisfied
- 4 : Quite satisfied
- 5 : Very satisfied

Submit Answer

Why did you give it that rating? (e.g. likes, dislikes, how did it satisfy your needs, how did it not satisfy your needs)

Answer:

Submit Answer

Considering the factors below and the ones that are most important to you:
- [Clear goal and expectations for learners]
- [Multiple representations of course content]
- [Frequent opportunities for active learning]
- [Frequent and constructive feedback]
- [Flexibility and choice in satisfying course objectives]
- [Instructor guidance and support]

How would you rate the design?

- 1 : Not satisfied
- 2 : Somewhat satisfied
- 3 : Satisfied
- 4 : Quite satisfied
- 5 : Very satisfied

Submit Answer

Why did you give it this rating?

Answer:

Submit Answer

Questions after looking through all the designs

Did any particular design suit your needs?

Answer:

Submit Answer

In order of preference, rank the designs from top to bottom.

Answer:

Submit Answer

Why did you give it this ranking? What is differentiating them for you?

Answer:

Submit Answer

Compared to the current database course, would you prefer to learn via your preferred design? Elaborate.

Answer:

Submit Answer

D.2 Online Learning Interview Questions

Questions								
An online learning platform is a website or mobile application in which you access the course materials and interact with the course.								
Which device would you prefer to access the online learning platform on?	Mobile Phone	Laptop/ Desktop PC	Tablet					
What makes an online learning platform relevant and easy to use? Please list 5 points and rank them from 1 (top) to 5 (bottom).								
What would you suggest is the best method of student-lecturer interaction in an online course?								
How would you structure this on an online learning platform?								
How would you like feedback in an online course?								
What presentation style of the course material would you prefer? E.g. Text, audio, video, etc.								
What suggestions do you have for the way tutorials and assignments are organized and structured?								
Would you like frequent testing of knowledge on the online learning platform?								
How important to you is it to have frequent testing?	Not important	Somewhat important	Indifferent	Quite important	Very important			
What kind of flexibility features would you like in an online learning platform?								
How important is each of the following to you in an online learning platform?	Clear goal and expectations for learners	Multiple representations of course content	Frequent opportunities for active learning	Frequent and constructive feedback	Flexibility and choice in satisfying course objectives	Instructor guidance and support		
	1 - Not important 2 - Somewhat important 3 - Indifferent 4 - Quite important 5 - Very important	1 - Not important 2 - Somewhat important 3 - Indifferent 4 - Quite important 5 - Very important	1 - Not important 2 - Somewhat important 3 - Indifferent 4 - Quite important 5 - Very important	1 - Not important 2 - Somewhat important 3 - Indifferent 4 - Quite important 5 - Very important	1 - Not important 2 - Somewhat important 3 - Indifferent 4 - Quite important 5 - Very important	1 - Not important 2 - Somewhat important 3 - Indifferent 4 - Quite important 5 - Very important		
What recommendations/suggestions do you have for improving online learning platforms in general. Please provide details.								
Just to know a bit more about your background...								
What is the highest qualification you hold (i.e. graduated with)?	Matric	Bachelors/ Honours	Postgraduate Diploma	Masters	PhD			
Which year of MIT are you currently in?	1st	2nd	3rd	4th +				
Are you a full-time or part-time student?	Full-Time	Part-Time						
Which MIT courses have you completed so far?	Web Programming	Social Issues and Professional Practice (Ethics)	Object Oriented Programming	Human Computer Interaction	Databases	Research Methods	Networks	Software Engineering
Which MIT courses are you enrolled for currently?	Web Programming	Social Issues and Professional Practice (Ethics)	Object Oriented Programming	Human Computer Interaction	Databases	Research Methods	Networks	Software Engineering
If you are interested in taking part in the design of an online learning interface (it will take about maximum a day of your time), please provide your email address here:								
Additional comments:								

Appendix E

E.1 Friedman Rank Test

The following equation was used to calculate the statistical significance of the ranks.

$$\chi_r^2 = \frac{12}{Nk(k+1)} \sum_{j=1}^{k} \left(\sum_{i=1}^{N} r_{ij} \right)^2 - 3N(k+1)$$

Where k = number of groups, N = number of blocks, rij = total of the ranks for group j. For k = 5 designs, N = 5 evaluators, and rij per the following table:

Designs	Evaluator 1	Evaluator 2	Evaluator 3	Evaluator 4	Evaluator 5	Rij
LECTURER2	1	3	1	1	1	7
STUDENTA1	3	1	2	3	2	11
CODESIGN1	2	2	3	2	3	12
STUDENTB1	4	4	4	4	4	20
LECTURER1	5	5	5	5	5	25

The χ_r^2 calculated is 17.12.

The following table is from (López-Vázquez & Hochsztain, 2019), which shows the critical values of χ_r^2 statistic for k=5 and N up to 12, including all cases where the relative error r > 10%, for significance levels α .

	0.100		0.050		0.025		0.010		0.005		0.001	
N = 2	7.200	[216]	7.600	[218]	8.000	[220]						
N = 3	7.467	[461]	8.533	[469]	9.600	[477]	10.133	[481]	10.667	[485]	11.467	[491]
N = 4	7.600	[796]	8.800	[808]	9.800	[818]	11.200	[832]	12.000	[840]	13.200	[852]
N = 5	7.680	[1221]	8.960	[1237]	10.240	[1253]	11.680	[1271]	12.480	[1281]	14.400	[1305]
N = 6	7.733	[1736]	9.067	[1756]	10.400	[1776]	11.867	[1798]	13.067	[1816]	15.200	[1848]
N = 7	7.771	[2341]	9.143	[2365]	10.514	[2389]	12.114	[2417]	13.257	[2437]	15.657	[2479]
N = 8	7.700	[3034]	9.200	[3064]	10.600	[3092]	12.300	[3126]	13.500	[3150]	16.000	[3200]
N = 9	7.733	[3819]	9.244	[3853]	10.667	[3885]	12.444	[3925]	13.689	[3953]	16.356	[4013]
N = 10	7.760	[4694]	9.280	[4732]	10.720	[4768]	12.480	[4812]	13.840	[4846]	16.560	[4914]
N = 11	7.782	[5659]	9.309	[5701]	10.764	[5741]	12.582	[5791]	13.891	[5827]	16.727	[5905]
N = 12	7.733	[6712]	9.333	[6760]	10.800	[6804]	12.600	[6858]	14.000	[6900]	16.867	[6986]
$\chi^2_{\alpha,(k-1)}$	7.779		9.488		11.143		13.277		14.860		18.467	

The critical value for χ_r^2 at k=5, N=5 is 14.4 for level of significance α = 0.001. χ_r^2 calculated is greater than χ_r^2 critical, hence the null hypothesis is rejected and the results are therefore significant at a 0.001 level of significance.