Meta-Design as a Catalyst of Effective Engagement to Encourage Learning Motivation at Scale: A Creative Coding Project

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Abstract

This research explores the relationship between creative coding online learning tasks and the encouragement state: a broad term for experiences that encourage or discourage an individual to cultivate motivation to learn. We describe a process of research through design in which a creative coding eLearning platform is redesigned, online learning tasks are classified through design patterns and a meta-design framework guides prior students to design online learning tasks for current students of Design Programming. This description covers the tools and methods used to conceptualise, prototype and implement these technological artefacts as design prototypes. We demonstrate that syllogistically informed design patterns in online learning tasks are associated with the encouragement state and through a combination of resources and facilitated workshops, meta-design can bring about the effective guidance of student-authored online learning tasks. We provide design guidelines that characterise this symbiosis of meta-design and eLearning, explaining it's application in a creative coding context and proposing its relevance to the learning process as a whole.

Acknowledgements

To all who have helped bring this research about,

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Chapter 1

Introduction

Learning to code for the first time can be hard. To understand a programming language, the instructions executed in a program must be clear in the learner's mind (Milne & Rowe, 2002). To switch between human reasoning and computational logic, the programmer changes their representation of, or the way they see, the programming steps. The inability to switch between representation is an identified root of programming difficulty (Kim and Lerch, 1997).

Creative coding is an avenue for students who may not fit the patterns of traditional programming to explore code concepts (Carvalho et al., 2014). Where traditional coding focuses on problem solving for efficiency, creative coding focuses on problem solving for creative expression. In this research, we adopt a research through design approach to explore student motivation in blended creative coding classes.

Consider the output of a creative coding artwork, such as those shown below in Figure 1.1.

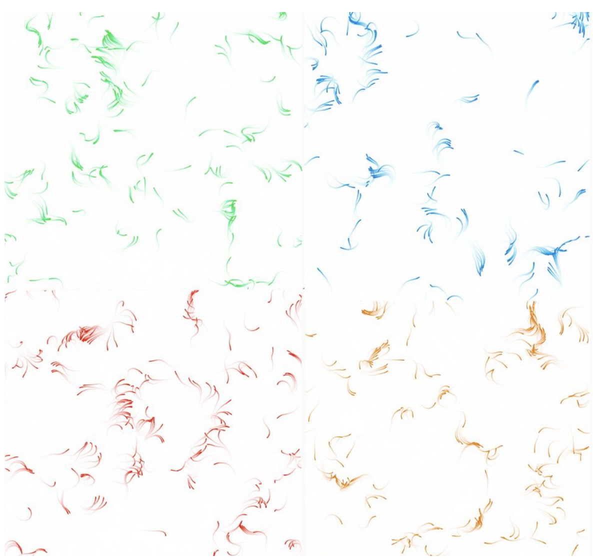

Figure 1.1 - A series of p5.js sketch outputs. see code here: https://editor.p5js.org/halcha/sketches/O18iWCFOu

The visual medium of creative coding provides instant feedback that can be a more intuitive way to understand programming concepts. Because the goal of art and design is often challenging to define, metrics for success are difficult to establish when teaching (Carvalho et al 2014). This tension means there is a need to consider how to teach creative coding students effectively.

We believe this tension could be addressed by effective use of online learning platforms. Online learning is the combination of web technologies and educational theory to facilitate learning. It's useful because of the accessibility it provides to students and teachers regardless of location or time of day (Ally, 2004). However, the value found in guided-time based goals, direct instruction and conversational guidance provided in a more traditional, offline teaching setting can be difficult to replicate online.

The difficulty of ensuring these factors are present in an online learning experience can contribute to unpredictable levels of academic success across a cohort (Song et al, 2004). We believe this unpredictability can contribute to the tension found in creative coding learning environments. Exploring methods of engaging students to increase their motivation may be a route to ease this tension, empowering students and tutors to navigate the unpredictable landscape that is online learning.

One such method may lie in student-led teaching. According to Guk and Kellogg (2007), students teaching students is a method to cultivate what Vygotsky termed 'internalisation'. Internalisation is the idea that in social environments, individuals observe and internalise the ideas and processes of their surroundings into new knowledge (Vygotsky, 1980).

We believe in an online setting, engagement and motivation between classes could be cultivated by creating an environment that encourages internalisation. When assignments become both a metric for academic success and a tool for social interaction, avenues for spontaneous time-based goals, direct instruction and conversational guidance may be opened. This may also ease the tension of online learning.

Over the course of our research project, Meta-design (Fischer & Scharff, 2000) of student authored learning tasks became a focus as a potential catalyst for student motivation. The idea was giving prior creative coding students a design guide for creating online learning tasks. This was in the hopes of galvanising their collective tacit knowledge into new knowledge (Backwell & Wood, 2011). This new knowledge was then given to new creative coding students as online learning tasks curated and edited by tutors.

As well as cultivating a culture of internalisation, we believe this could yield two main benefits. The first is time required for creating resources is distributed among tutors and students. This would give tutors more time to focus on the editing and curating of teaching resources. The second is the relatability of online learning is increased. With only a semester of experience between prior and current students, tips and tricks prior students would have loved during their semester can be passed onto the current students.

The interaction between student cohorts and design artefacts is observed in this research. In Semester 1 of 2020 there was a student cohort who learnt p5.js for the first time in the Design Programming Course. In Semester 2 of 2020, they studied Web Design and Technologies. The first assessment was to create an online learning task teaching design programming students a p5.js concept. In the latter subject, they are guided to create these online learning tasks through a meta-design framework. The exemplary student challenges will be passed on to the Design Programming students of Semester 1 2021. This relationship between cohorts addresses aspects of online learning, motivation in learning and meta-design theory.This research is part of a larger research endeavour, the Creative Coding Challenges project. The team collectively engaged in interaction design, software development, and educational content development. This research focuses design and development involved research objectives and makes note of tasks conducted as a team.

Using the Research through Design (RtD) theoretical framework (Zimmerman, Forlizzi and Evenson, 2007) we design, develop and evaluate online artefacts to deepen our understanding of the relationship between creative coding online learning tasks and the encouragement state. The encouragement state is a broad term for experiences that encourage or discourage an individual to cultivate motivation to learn. We then use this understanding and aim to create a guide for designing online learning tasks that students associate with a positive encouragement state to explore the effective meta-design of student authored online learning tasks in a creative coding environment.

1.1 Aim

To explore how meta-design can improve student-made online learning tasks and the relationship between online learning tasks and it's encouragement of an individual's cultivation of motivation to learn.

1.2 Research Objectives

Q1: Explore the effects of design patterns in creative coding online learning tasks (OLTs) on student engagement and how this encourages cultivation of learning motivation.

- What design patterns encourage and discourage cultivation of learning motivation?
- What is the relationship between design patterns and instructional strategy?

Q2: Understand how students design learning activities, particularly online creative coding tasks.

- How do students approach learning task design?
- What are the perceived benefits of articulating the learning process?

Q3: How can meta-design effectively guide the student-authorship of creative coding OLTs?

- Does a meta-design approach to student-led teaching create more effective learning activities? If so, how?
- Does the meta-design approach make a more enjoyable experience when creating learning activities?
- What are some design considerations when facilitating meta-design of creative coding online learning tasks?

1.3 Motivation

Online learning has been considered effective, due to the "ubiquity and multiplicity of human and agent communication" (Anderson, 2008). While this makes it a powerful tool for education proliferation, its disadvantages can create a poor learning experience. This difficulty of including guidance and social interaction in online learning (Song et al, 2004) increases the diversity in approaches students take to reach objectives in online learning environments. This diversity brings varying degrees of success for students.

COVID-19 has made physical distancing policies the norm around the world. Because of this, online learning has become considered the primary method of education (Adnan & Anwar, 2020). This has emphasised the diversity of online learning success and is considered a vital area of research to maintain and improve global education standards (Verawardina et al., 2020).

A recent study by the Tertiary Education Quality and Standards Agency (2020) collected a review of Australian University student sentiments to positive and negative aspects of online learning. This study reports 34% of its responses expressed a lack of or inadequate academic interaction. Between 20% and 25% of responses expressed flexible access to materials. We believe through online learning improvement, negative aspects can be reduced.

Online learning improvement has been attributed to effective communication of instructional strategy. Clark (1983) considers instructional strategy is the determining factor of student achievement and not technology. Alternatively, Kozma (2001) argues attributes of technology are required to bring simulations to the learner. If these simulations are more effective in the communication of instructional strategy to alternatives, then technology plays an important role in student achievement of that context. We interpret these views as the following: effective online involves the interplay of instructional strategy and technology. The motivation of this research is that through effective online learning, student experience can also be improved. This improvement aims toward an alleviation of unnecessary education related stress to contribute to an improvement in student quality of life.

1.4 Significance

This research has the potential for creating a self sustaining programming education framework for online learning. When students are able to contribute to each others' learning by creating effective and engaging online learning tasks, they pass on their knowledge so new students can pass on theirs.

Nuthall (1999) identified tasks that increased levels of trust, sharing, acceptance and mutual support were cognitively effective in helping students achieve learning outcomes. The presence of a framework which effectively outlines the benefits for the student creator and student learner would achieve these heuristics to create cognitively effective tasks.

The facilitation of social dynamics between student cohorts aims to begin a culture shift. This shift transforms the teacher's responsibilities from content development to curation and guidance. Alton-Lee (2003) identified a key role of the teacher as "[having] knowledge of the nature of student learning processes" and interpreting "student behaviour in light of this knowledge".

In a computer science context, Guzdial (2015) notes "When describing how students perceived the curriculum in computer science courses, these studies used words like 'tedious,' 'boring,' and 'irrelevant.'" While tedium and boredom make sense due to the necessary "attention to detail" in computer science, relevance was an interesting result. Students from a 2004 study found students recognised the relevance of programming education but not for their personal academic context. (Rich, Perry, & Guzdial, 2004).

Alton-Lee's (2003) findings would suggest a perception of programming education having personal relevance could be fostered through a focus on personal learning orientation. This is summarised in Brophy's research on links between learning orientation and student outcomes:

> *"The teacher promotes a learning orientation by introducing activities with emphasis on what students will learn from them, treating mistakes as natural parts of the learning process, and*

> *encouraging students to work collaboratively and help one another."* (Brophy, 2001)

By alleviating the need for teachers to create content, teachers can focus their attention on learning orientation through curation and guidance. Teachers would have the resources to orient students through a narrative that connects available content to be "responsive, creative and effective in facilitating learning processes." (Alton-Lee, 2003). This content would be a modular guiding resource without the need for a tutor to provide support. This lack of support requirement allows content to collectively form a sustainable online environment.

Another point of value arising from this research is a process to create a dataset for learning recommender algorithms in the eLearning platform. Without a large and reliable dataset, the regression analysis i.e. line of best fit, that predicts challenge recommendations is inaccurate. Establishing a process for the collection of effective teaching resources provides potential for a dataset on which accurate regression analysis can be applied.

1.5 Overview

Figure 1.2 below illustrates a visual map of this research as an overview. See Chapter 4 for more details on this RtD Process.

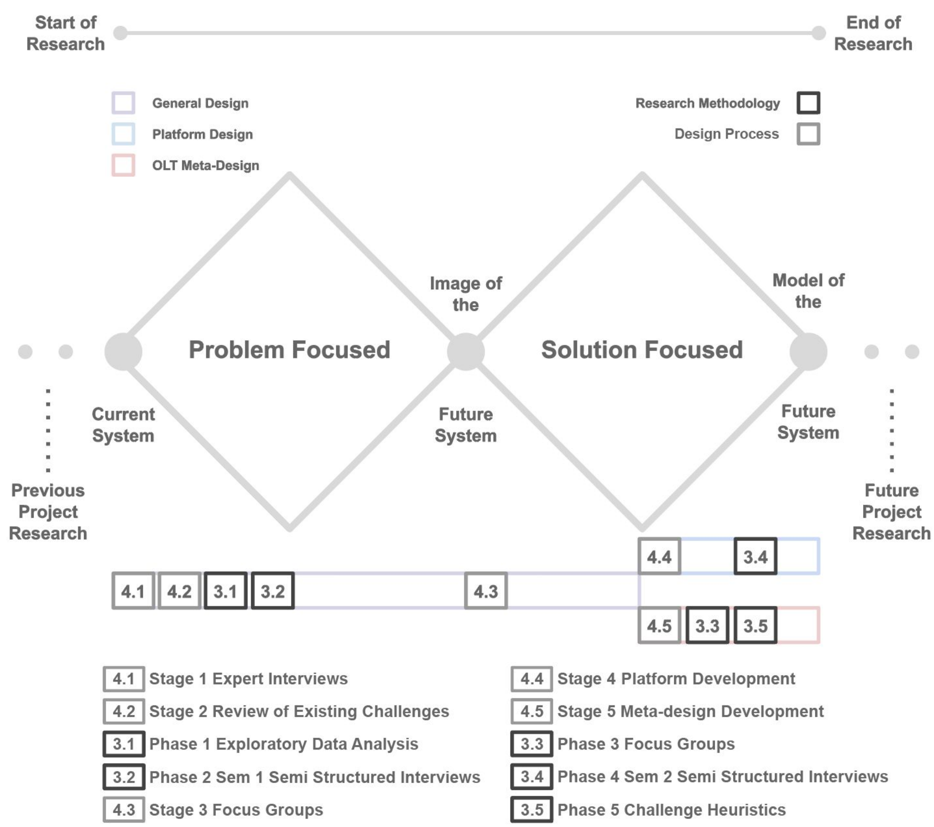

Figure 1.2: An Overview of our Process of Research through Design.

The RtD process integrates research and design to use designerly aspects of prototyping and evaluation as valid methods of enquiry (Zimmerman, Stolterman & Forlizzi, 2010). We present our RtD process as discrete activities of design and research to provide clarity. We refer to these activities as Design Stages and Research Phases.

Chapter 2 details a literature review that provides a background for these activities, considering established theories and principles of online learning, motivation in education, meta-design and its application in student-led teaching and the RtD Process.

Chapter 3 describes the methods used to analyse and evaluate the research environment and technological artefacts integrated during the RtD process. These methods are separated into 5 phases visualised at the bottom of figure 1.2. Each phase considers a different facet of research objectives (see Section 1.2) to more accurately deepen our understanding.

Chapter 4 explores the process of utilising research findings to establish the design problems within the research environment, conceptually design solutions through feedback based iteration. This informs mockups of low to high fidelity solution visualisations that provide a blueprint to create OLT and meta-design prototypes for validation. This validation of design prototypes provides data for evaluation; the analysis of which deepens our understanding of research objectives. The design process is separated into 5 stages visualised in tandem with the 5 research phases at the bottom of figure 1.2. This visualisation represents the interconnection between research and design in the RtD process which has been separated for clarity.

Chapter 5 summarises the results of research methods described in Chapter 3. They are communicated through visualisation and summative conclusions are drawn for further discussion in Chapter 6.

Chapter 6 discusses results as a reflection of research objectives. Designs patterns in eLearning are considered through their relationship with the encouragement of a student's individual cultivation of motivation to learn. Student-led teaching using these design patterns is explored as a catalyst for the learning process. meta-design of student-led teaching is presented as a process to proliferate student-led teaching in online learning and increasing skill efficacy and the cultivation of motivation to learn.

Chapter 7 summarises the discussion and provides the key insights of this research.

Chapter 2

Background

Three areas of literature have been identified as critical areas of exploration to ground this study: research into online learning, research on motivation in learning to program and research into the design of meta-design frameworks that encourage student-led teaching. Research through Design (RtD), the process through which this research was conducted, is also summarised here.

2.1 Online Learning

Online learning is a subset of educational technology that uses web technologies to facilitate learning. It is understood the acquisition of knowledge, personal meaning and growth can be found through interaction with and support of learning materials, peers and teachers in an online setting (Anderson, 2008).

To discover the origins of instructional strategy present in online learning today, we explore the history of educational technology (see Section 2.1.1). To articulate the process of proliferation of online learning and the frameworks used today, we look at online learning in higher education (see Section 2.1.2). Finally, we consider the online learning task (OLT) as a collection of teaching resources oriented towards a goal. The student engages in this OLT to develop new knowledge. This consideration reveals the origins, principles and practices of online learning that provide a foundation for our objectives as we conduct research in an online learning context.

2.1.1 Educational Technology

Educational technology can be described as a persisting initiative that seeks to bring learners, teachers, and technical means together in an effective way (Mangal & Mangal, 2008).

According to Nye (2007), the effectiveness of this initiative has historically been measured through four metrics:

1. degree of ease for learners
2. speed of proliferating new knowledge
3. accuracy of knowledge taught

4. cost efficiency

Nye implies educational technology from the cave paintings to virtual reality broadly changes and improves according to these four metrics. These general principles provide a useful foundation for specific instances of educational technological innovation.

Early instances of humans delegating logical processing to tools are the abacus, writing slate and blackboards. The former is thought to have been used from about 2700BC (Ifrah & Harding, 2001) and the latter from about 1030AD (Sachau, 1993).

While many calculation technologies have surpassed the abacus, the most popular educational technology for instructional delivery, the blackboard, has maintained supremacy for almost 1000 years. This supports Clark's idea that technologies are merely vehicles that deliver instruction, and do not themselves influence student achievement (1983).

As needs for quickly assessing skill efficacy were recognised, technological and systems innovation emerged. The First World War saw use of the first all multiple choice, large scale assessment "Army Alpha" to quickly determine intelligence characteristics for selected deployment (Yoakum & Yerkes, 1920). Educational films of the 1900s and mechanical teaching machines of the 1920s marked the use of media and computational devices as new initiatives to bring about new knowledge (Seattler, 1990).

The Second World War brought with it another major need for quick education. This resulted in another increase of large-scale education technology for military use such as films via overhead projectors. Concurrently, Vanaver Bush put forth the Memex idea in the 1945 Atlantic Article 'As we may think' (Bush, 1991). The memex was conceptual a device that indexed the memory or library of the individual to increase the ease and speed of access to information. This would be the foundation of hypertext, an underlying concept of the world wide web.

Pre-internet, Learning Management Systems (LMS) for accounting and engineering mainframes became the dominant use of new educational technology. The aim of which was to quickly upskill technical employees to operate the private "Memex's" that held and calculated a company's information (Szabo, 2002).

Since the economy growth continued with mainframes consuming the lion's share of capital and programming talent, It was many years before the internet enjoyed widespread adoption (Szabo, 2002). As personal computing expanded and the mainframe receded, the Internet became a driving force in educational technology. Created by Sir Tim Berners-Lee in 1969 while at the department of defence, the Internet was, according to some scholars, introduced to the world in 1991 (Perry & Pilati, 2011).

Since then, online learning, also known as ‘e-Learning’ has proliferated and transformed how we consider education today. The council of Europe has endorsed e-learning as having the potential to drive equality and improve education (2008).

Online learning systems have developed an nexus through which teaching resources are distributed during learning experiences. They have been described as a means and not a mode (Nichols, 2003). User interaction is recorded as part of these systems, the goal of which is to improve the experience (Courts & Tucker, 2012). Studies of e-learning experiments conclude that eLearning success relies on expert investment into harnessing the wisdom of crowds and social collaboration (Tarasowa, Khalili & Auer, 2015) (Martinez & Walton, 2014) (Golub & Jackson, 2010). This focus on connection and collaboration, like the technology it sits in, is the key difference between mainframe LMSs and eLearning systems.

This research was undertaken during the 2020 global pandemic. The situation has quickly revealed the need for flexibility in how we use educational technology as a global community (Sneader, 2020). The global initiative is transparent; UNESCO’s index of distance learning solutions providing ample examples of efforts to ensure quality education is maintained and improved (Global Education Coalition, 2020).

In published eLearning systems research, a new consensus is emerging: eLearning systems are the way towards maintaining physical distancing in education without sacrificing social interaction and quality learning experiences. (Dhawan, 2020) (Adnan & Anwar, 2020) (Verwardina et a., 2020).

In this research we explore avenues to create and improve upon quality learning experiences in the context of creative coding education.

2.1.2 Online Learning in Higher Education

Even before the internet, there were communities of researchers working towards the quick and easy proliferation of knowledge regardless of distance. These communities were in the field of distance education (Keegan, 1996). Correspondence by parcel was a method of distance education in the 1800s: an effort to assist students who couldn’t be on campus (Kentnor, 2015).

The history of online learning in higher education holds similar roots to that of educational technology (see Section 2.1.1). A key difference between these two scenarios is the rate at which proliferation occurred. Due to the available technology, higher education catalysed the proliferation of eLearning innovation where it would otherwise progress slowly (Nye, 2007). This becomes apparent when comparing the evolution speed of distance education and online learning.

Consider the steps after correspondence by parcel were educational broadcasting via radio in the 1920s and educational television experiments in the 1930s (Kentnor, 2015). After the usual delay in adoption, the benefits became apparent and were deemed a success by the public. In the 1950s, the United States Federal Communications Commission began reserving television frequencies for educational purposes.

Compare this with the evolution of online learning. In the 1980s, the widespread adoption of the mainframe LMSs for companies was a contribution to elearning proliferation with public benefit perceived through vast economic growth (Szabo, 2002). In an educational context, mainframe LMSs were seen in college libraries and known as Computer Based Learning systems. These systems provided computer drills and micro-world simulations (Balacheff & Kaput, 1996). At the University of La Jolla California, the School of Management and Strategic Studies used video conferencing as a method to deliver distance education to business executives. This has been called the first instance of what we see as eLearning today (Feenberg, 1993).

The existing instructional strategy of online learning coalesced in technologies surrounding the Internet. Because of the opportunity for iteration based on quantitative data analysis of student experience, the complexity of eLearning design compounded (Bakharia et al. 2016). It was the complexity inherent in eLearning systems that radically changed the requirements for instructional strategy (Berggren et al., 2005). Broad economic factors concerning the speed of which this technology could potentially teach many people encouraged greater collaboration between industry and higher education (Bramble & Panda, 2008).

By comparing the evolutions of distance education and online learning, two things are revealed. The rate at which educational technology evolves in and out of higher education is accelerating in the form of eLearning. With this, acceleration of global collaboration between industry and education communities also increases. Despite the flaws of eLearning this his is undoubtedly a positive outcome. The key to successful evolution, some have suggested, lies not in innovation but integration of effective teaching experiences as part of these systems. According to Clark (1983), instructional strategy, not technology supports student achievement.

In this research, we've considered how the acceleration of technology provides an opportunity for students to be more involved in the creation process of online content in higher education.

2.1.3 Online Learning Tasks

An Online Learning Task (OLT) is a set of resources and instructions provided to a student to complete a specific objective. A collection of OLTs are known as Learning Objects. A Learning Object is "a collection of content items, practice items, and assessment items that are combined based on a single learning objective." To adapt to the changing requirements of an eLearning system, Learning objects became classified in Learning Object Frameworks (Berggren et al., 2005). In scenarios of converting existing courses to online learning, an eLearning system without a framework may be unorganised and confusing. With such a framework, eLearning provides intuitive learning experiences (Georgouli, Skalidis & Guerreiro, 2008).

Clark & Mayer (2008) developed a Learning Object framework that consists of five content classes through which learning can manifest. Table 1 shows a description of these with examples related to the context of this study. In practice, multiple content classes are present in learning experiences. (Clark & Mayer, 2008).

Class	**Description**	**Example**
Fact	Unique data	Logical operators or the syntax of a function.
Concept	A category that includes multiple examples	Transforming Shapes or Gestalt Principles and their effect on the perception of art.
Process	A flow of events or activities	Recursion or mouse interaction with an output.
Procedure	Step-by-step task	Entering a series of methods into a canvas to produce a specific visual output.
Strategic principle	A task performed by adapting guidelines	Encourage someone viewing your artwork to consider the concept of time using specific visual outputs as stimulus for meditation.

Table 2.1: Content classes of a Learning Object framework (after Clark & Mayer 2008)

In this research, Clark and Mayer's content classes inform the design of OLTs which are used in a RtD process to deepen our understanding of our research objectives. Using the insights on education technology and online learning, the engaging effects of these OLTs were analysed to better understand how the relationship between design patterns and learning motivation.

2.2 Motivation in Education

"Buddha saw that all his yoga exercises and ascetic disciplines had just been ways of trying to get himself out of the trap in order to save his own skin, in order to find peace for himself. And he realized that that is an impossible thing to do, because the motivation ruins the project." (Watts, 2005)

There are many theories on how motivation affects the success and enjoyment of a particular task or goal. In this research, we explored theories that relate to OLT learning experience. Assuming the understanding of some scholars, that OLT success is dependent on self-efficacy (Shen et al., 2013), we focused on three areas of research: Self Determination theory, Social Interaction in Education and Scaffolding.

2.2.1 Self Determination Theory

As an evolution of studies on intrinsic and extrinsic motivation, Self Determination Theory (SDT) is concerned with the choices people make with external influence or interference (Deci et al., 1991) (Ryan & Deci, 2000). A key reason for SDT's emergence was the overjustification hypothesis. This hypothesis states 'a person's intrinsic interest in an activity may be decreased by inducing him to engage in that activity as an explicit means to some extrinsic goal' (Lepper, Greene & Nisbett, 1973). Ryan and Deci classified the three psychological needs to determine the path of the self i.e. self motivation. These are competence, autonomy and relatedness (Ryan & Deci, 2000).

The need for competency was first understood through the increase of intrinsic motivation through unexpected positive feedback (Deci, 1971). This increase was also found to decrease extrinsic motivation for a task (Vallerand & Reid, 1984). It is the interplay of personal and group perception of an individual's competence in a goal or task that affects both intrinsic and extrinsic motivation.

SDT researchers first understood the need for autonomy through an observation of the individual's desire to demonstrate causal agency in their own life that acts in harmony with their interests and values (Deci & Vansteenkiste, 2004). It was found to be a variation of the overjustification hypothesis: through the absence of forced extrinsic motivation, intrinsic motivation was cultivated and with it, a sense of autonomy (Amabile, DeJong & Lepper, 1976).

Amabile, DeJong & Lepper's study (1976) provides an example of autonomy and its effect on interest . Two groups of 20 students worked on a series of 'initially interesting word games'. The first group were given a time limit, the second were not. Each group ran the session twice. In one run, the first group were told they must finish all the games within the time limit. In the other, instructions were left implicit while they were aware of time being kept. In one run of the second group, they were advised to work at their own pace. In the other, it was requested they finish the word games as fast as they could.

To draw an analogy, it is said when Gautama Buddha realised it was his striving (through ascetic means) to reach enlightenment that was stopping him, that was the moment he was enlightened (Watts, 2005). These examples demonstrate that the need for harmony between extrinsic and intrinsic motivation manifest in the need for autonomy.

The need for relatedness is the combination of the social dynamics of a learning environment with the fundamental need to belong (Baumeister & Leary 1995). From this combination, three principles emerge (Deci & Vansteenkiste, 2004).

1. Humans are inherently proactive with their potential and mastery of their inner forces (such as drives and emotions)
2. Humans have an inherent tendency toward growth development and integrated functioning
3. Optimal development and actions are inherent in humans but they do not happen automatically

Relatedness can be also be considered as a combination of the need to belong and the wisdom of crowds (Martinez & Walton, 2014). One can learn from the mistakes of the collective to maximise their inherent potential while feeling a part of the community. Social aspects of motivation like relatedness are further explored in Section 2.2.2.

As a practical interpretation of SDT, some scholars suppose that student self-assessment can promote intrinsic motivation and bring about meaningful learning. According to McMillian and Hearn (2008), when students identify criteria for improvement and set goals through reflection, meaningful motivation and improved performance emerges. The acts of criteria identification and goal setting in tandem have been shown to be practical manifestations of Ryan and Deci's competence, autonomy and relatedness (2000).

Environments best suited for student self assessment are student centred environments. This environment encourages focus on the interaction between a student and the resources as the primary channel for activity progression (Kaplan, 2017). According to Wagner and Combs (1995), OLTs provide ideal circumstances for these student centred environments.

Based on the literature covered, we assume that motivation is dependent on individual cultivation. We also assume this cultivation can be encouraged or discouraged by their environment. Hereafter, when referring to the cultivation of an individual's learning motivation that occurs whilst engaging with technological artefacts of this research environment, we will use the phrase 'encouragement state'. The state will be referred to as positive or negative, depending on the encouragement or discouragement of an individual's cultivation of learning motivation. In other words, a positive encouragement state means that the individual is incentivised to cultivate their own motivation to learn, while a negative encouragement state means that they are disincentives.

This research explores the positive or negative manifestation of the encouragement state as aspects of student self assessment are integrated in OLTs; a technological artefact our of Research through Design process.

2.2.2 Social Interaction in Education

When exploring social interaction in education, we focused on Social Interactionist Theory (SIT) as an expansion of Relatedness in SDT (Baumeister & Leary 1995). SIT is the theory emphasising and characterising aspects of social interaction in the context of education. SIT holds its origins as a linguist theory. It began as an explanation of the child's development of their first language learnt from 'linguistically knowledgeable adults' (Vygotsky, 1980).

According to SIT, effective social interaction in education encourages students to reach the zone of proximal development (ZPD). The ZPD classifies a learning experience where a student completes tasks otherwise impossible. They do this through 'guided participation'. The result of this is the acquisition of what Vygotsky refers to as 'new language'. After this acquisition the student acquires the ability to complete the task by themselves (Wood & Wood, 1996). This acquisition of 'new language' is not limited to guided participation in partnerships but can also be found through the social mediation of the collective (Wood & Wood, 1996). If we assume that a language is essentially a way of thinking (Watts, 2017), This new language could be any skill or discipline.

The flipped classroom method is a practical method that exemplifies this idea of collective social mediation when learning a new skill or discipline. Bishop and Verlerger's review of flipped classrooms states that flipped classrooms use 'asynchronous video lectures and practice problems' outside of class and 'active, group-based problem solving activities' in the class.

Essentially, students prepare individually and solidify new knowledge during problem solving activities together (Tucker, 2012).

It was found in the cases where someone didn't prepare for class, social pressure to achieve is palpable. This pressure however is not stemming from an authority figure but from their peers. The situation of peers as mentors through social pressure provides a harmony of flexibility and structure that has been shown to better position students in the ZPD than traditional classroom methods (Bishop & Verleger, 2013).

In this research, we explore SIT in our OLTs through the integration of student self assessment. We also explore specific aspects of the flipped classroom method such as student led teaching, and the effect this has on a student's motivation to learn when integrated into our technological artefacts.

2.2.3 Scaffolding

Scaffolding is defined in an education context as the support given to a student during the learning process. It is a method of student centred learning, which tends towards a more efficient positioning of learners in the ZPD than traditional learning methods (Sawyer, 2005).

This term was coined in the mid 1960s by Jerome Bruner to describe the language acquisition of young children. Bruner described that even from a very young age, a learner can learn any material so long as it is effectively organised (Bruner, 1966).

Bruner suggests effective scaffolding encourages fluidity of student representation. He organised representation in three categories: enactive (action-based), iconic (image-based) and symbolic (language-based). Through effective scaffolding, a student can translate between the representation of knowledge in a dynamic way that brings about new knowledge. This idea is in part the basis of the Vygotsky's ZPD in that 'guided participation' encourages fluidity of representation (Vygotsky, 1980). When paired with Social Interaction (see Section 2.2.2), an effectively scaffolded environment includes social interaction. This harmony of structure and social expression is a representation of the effective environment for positioning a student in the ZPD.

There are three essential features of Scaffolding (Wood & Wood, 1996) (Beed, Hawkins & Roller, 1991). The aim of these features is to facilitate learning:

1. Collaborative interaction between the expert and the learner.
2. Learning takes place in the ZPD (see Section 2.2.2 for its definition).
3. As learner proficiency increases, the scaffolding is removed.

The third rule can be thought of as the removal of scaffolding during the construction of a building. According to Palincsar, 'a scaffold is a means of providing support that is both adjustable and temporary.' (1986). This research focuses on programming language acquisition, a stage of learning to code consisting almost entirely of acquiring new concepts or skills. The suitability of scaffolding to the environmental context of this research made it a promising teaching method to explore.

In combination with Student Self Assessment and Social Interaction, Scaffolding is used as a key teaching method that guides the design of the technological artefacts created as part of this research. This combination provided a set of methods that were integrated into the assessment guide to guide OLT creation. This framework was the meta-design of a student-led teaching experience.

2.3 Meta-design of Student-led Teaching

Student-led teaching is a method of student self-determination within a learning experience. The method holds origins in a constructivist approach to education: a theory that recognises the experience and knowledge students have acquired prior to entering school as the basis for new knowledge (Matthews, 1998). From this theory, we consider that school, or any educational experience, influences what we learn after said experience. According to Gijselaers (2000), it is impossible to teach a student all their lives. He concludes this theory emphasises the desire to prepare students with tools to teach themselves. This effective instruction manifests through student led teaching methods (Lunenberg & Korthagen, 2003). Another perspective through which scholars have studied tools for autodidactic learning is Active Learning Theory.

Bonwell and Eison (1991) define active learning theory as "Anything that involves students in doing things and thinking about the things they are doing". In consideration of the similarities observed between active learning, student self-assessment and SDT as well as the applicability of these theories in a scaffolded environment of guided participation through social interaction, we explored instances of systems through which such a collaboration could emerge in a creative coding context. This led us to the theory of meta-design.

Meta-design is a conceptual framework for collaborative design. The aim is to nurture concepts through the wisdom of crowds that harnesses the collective perspective. (Golub & Jackson, 2010). This conceptual framework consists of conceptual tools. Conceptual tools are the analytical instruments that create meaning within and between dynamic contexts (Ravitch & Riggan, 2016). The effectiveness of meta-design is dependant on the following four conceptual tools (Vassão, 2019):

1. Levels of Abstraction - collective understanding of the structure and limits in an abstract thought.
2. Diagrams and topology - collective understanding of diagrams based on topological philosophy
3. Procedural Design - create realities through procedures e.g. a role playing game to increase collective understanding
4. Emergence - collective ability to take advantage of unintended and unforeseen results i.e. exploratory data analysis, through the absence of absolute control.

Meta-design provides an avenue to combine student self assessment with guided participation. The collaborative nature of meta-design has been shown to convert collective, tacit knowledge into new knowledge (Backwell and Wood, 2009). In combination with Student Self Assessment methods to bring about Self Determination in a scaffolded context, the technological artefacts provided through the meta-design of a student-led teaching experience became a key focus of the environment this research explores. The exploration is done through a Research through Design process.

2.4 Research through Design

‘Certain phenomena are "artificial" in a very specific sense: they are as they are only because of a system's being moulded, by goals or purposes, to the environment in which it lives.’ - (Simon, 1996)

Due to the complexity of systems design in the 21st century, there is a need to separate design from design research (Bayazit, 2004). It became the task of the design researcher to integrate the ‘synthesis’ of engineering with the ‘analysis’ of science (Simon, 1996). Principles and practices have been established to effectively articulate and generate insights from the design process. They have been collectively referred to as the Research through Design (RtD) process (Zimmerman, Forlizzi & Evenson, 2007). The research methods in this study are structured according to this process.

As an example of a singular method, the pre-pattern method (Chung et al., 2004) aims to use artifacts made through design as a template for future work in a similar context. The frameworks on online learning tasks (see Section 2.1.3), scaffolding (see Section 2.2.3) and the meta-design of student led teaching (see Section 2.3) are examples of this method. In this study, we use the pre-pattern method by analysing the findings from previous studies as a foundation. These are analysed for applicability to the context of our study and inform the research methodology taken. By following this method effectively, studies can build on the insights previously gleaned from the evaluation of artifacts and therefore progress more efficiently (Chung et al., 2004).

Like the pre-pattern method, there are numerous methods devised to better create the right solution for a given problem. Zimmerman, Forlizzi and Evenson (2007) proposed a model in four 'lenses' to distill the aggregate goal of focusing research on the problem, not in choosing the method to solve it. Below are these lenses which as a guide of evaluation can distinguish good design.

1. The first lens of this model is the process. A focus is ensuring rigour and rationale when engaging in and evaluating the use of research methodology.
2. The second is invention. To demonstrate novelty through integration of relevant subject matter is to demonstrate an aspect of good design.
3. The third is relevance. An articulation of the preferred environment state with evidence of it's support from the collective combined with a real (as opposed to semantically true) account of events is the essence of relevance.
4. The fourth and final lens is extensibility. If method or knowledge can be built upon, this is an aspect of good design.

In following this formalisation, we were wary of the unfalsifiability that is intrinsic in Research through Design. According to Popper's criterion of falsifiable scientific theory, design research is unfalsifiable due to the vague and subtle nature of the theories that ground the practice (Popper, 2014). However, as design is an artificial science, the task is not to obtain simplicity from the complexity of a given environment but to understand how things '*ought* to be in order to *attain goals'* (Simon, 1996). It is this subtle nature of RtD theory that allows society to capture and proliferate the right ways to design artifacts and systems that improve experience in a given environment. (Zimmerman, Stolterman, Forlizzi, 2010).

In this research, we have gathered findings that emerged from it's specific context. By doing so through consideration of process, invention, relevance and extensibility, we believe these findings will find applicability in other contexts. Furthermore, situations will emerge when the artefacts involved ought to be of a likeness to what our findings suggest. Through considering this research the solutions to these situations may be more easily discovered.

Chapter 3

Research Methodology

This research was divided into 5 phases of evaluation to deepen our understanding of the research objectives. These phases explored the effect of design patterns, how students design OLTs and how to meta-design on OLTs. Figure 3.1 below visualises the phases as part of the RtD process. As a process, the insights from this collective understanding led to the refinement of technological artefacts that, in turn, could be validated as a means to gather further data (see Chapter 4 for detail).

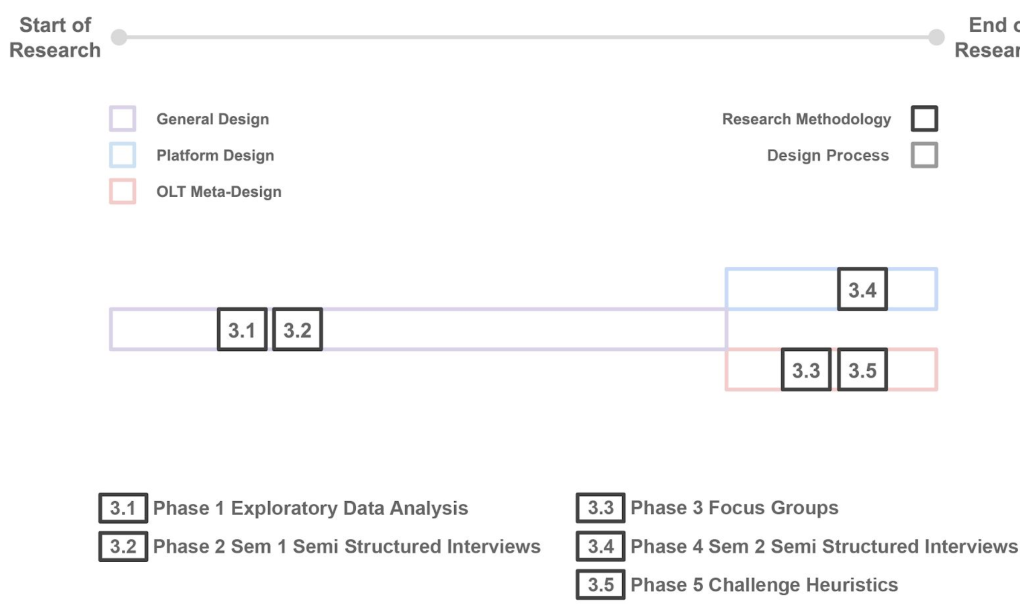

Figure 3.1: The phases of research in our RtD process.

The aim of the first, second and fourth phases was to deepen our understanding of the relationship between design patterns and the encouragement state: on the encouragement and discouragement of a student's individual cultivation of motivation to learn. Phases 2 and 4 of Research were conducted collaboratively with another honours student as part of the Creative Coding Challenges Project. Phases 1, 3 and 5 were conducted individually for the exclusive purposes of objectives in this Research.

The first phase (see Section 3.1) did this from a quantitative perspective. The second phase (see Section 3.2) followed up on this through qualitative enquiry. The third (and fifth) phases are discussed below, as they both relate to the meta-design concept that emerged during our research. The fourth phase was also qualitative but used a second iteration of our design prototype as the focus of enquiry (see Section 3.4). This process allowed us to compare the effect of our design patterns as perceived by students. Through this iterative process, we gained a more concrete understanding of the relationship between design patterns and the encouragement state.

The third and fifth phases explored metadesign, specifically how students design their own creative coding OLTs learning activities, particularly online creative coding tasks. These phases allowed us to explore how meta-design can effectively guide student authorship of creative coding OLTs. The third phase did this qualitatively, through the collective perspective of a cohort using an assessment guide that acted as a meta-design framework (see Section 3.3). The fifth phase explored both qualitative and quantitative aspects of the framework. This was done by analysing expert heuristic evaluation of the top 10% of meta-designed OLTs (see Section 3.5.1). This analysis was compared with the distribution of assessment marks for non meta-designed OLTs and meta-design OLTs.

Hereafter, we will use the word 'challenge' to refer to an Online Learning Task (OLT) in the specific eLearning system used in our research. We will use the phrase 'student-authored challenge' to refer to OLTs created by students through the meta-design framework of this environment. In aggregate, the evaluation phases gave us a deeper understanding of the effect of design patterns in challenges and the meta-design of design patterns in student-authored challenges on encouragement state to inform iteration of design prototypes as per the RtD method (Zimmerman, 2007). This iteration then allowed for validation of prototypes which further deepened this understanding.

3.1 Phase 1 Evaluation: Exploratory Analysis of Challenge Feedback Data

The goal of Phase 1 was to explore the first research objective (see Section 1.2). We did this by gaining a general understanding of the effects of challenges on the encouragement state of students engaging in challenges. As an individual research phase, this was conducted individually as the results pertained to the objectives of this research. However, results were shared with the research team and used in the interview process involved in Phase 2 (see Section 3.2). At the start of 2020, the existing eLearning platform contained a set of staff-authored challenges that, upon completion, students were able to review with a set of Likert scale questions. This data had not, at the commencement of this research project, been analysed. The dataset analysed was written in JavaScript Object Notation (JSON). To simplify the dataset for analysis, we wrote a script in a parsing language called JQ. This script retrieved the results of answers to Likert scales for Understanding, Enjoyment, Ease and Learning and mapped them by student and challenge as a spreadsheet. Submission times were recorded and compared with Likert Scales, revealing the changes of encouragement state over time during Semester 1. This script allowed us to update the dataset dynamically during the research. We based subsequent research through design in part on this dynamic data. The results presented in Section 5.1 represent all available data from the dataset after the conclusion of Semester 1 2020.

The feedback metrics in the dataset consisted of 4 separate Likert Scales. The Likert Scale is a method for measuring attitudes (Likert, 1932). This method has been reported as 'one of the most fundamental and frequently used psychometric tools in educational and social sciences research' (Joshi et al., 2015). This dataset contains scores between 1 and 5 given by students for four aspects of challenges: Understanding, Enjoyment, Ease and Learning. The question format is illustrated in figure 3.2 below.

Figure 3.2: The feedback form a student completes after completing an OLT

Exploratory data analysis (EDA) was used to further our understanding of student perspectives of their personal encouragement state during challenges. This understanding helped identify positively and negatively encouraging challenges for individuals and explore commonalities of the cohort. According to Tukey (1962), EDA consists of ways to plan the gathering of data. This is then analysed through exploratory techniques for data interpretation. The aim of EDA is easier, more precise or more accurate analysis. As an interpretation of EDA, we attributed design patterns observed in challenges with classifications. These classifications were compared by collective perception of encouragement. This comparison provided a general understanding of the effects of design patterns in challenges on the encouragement state and can be found in the results (see Section 5.1).

3.1.1 Participants

Our participants consisted of the students from the Semester 1 cohort of the Design Programming Course in 2020. Students were given an opt-in choice for their data to be a part of this study so the sample consisted of those who made that choice. As this course is run in multiple streams across the university The total sample consisted of 396 participants (n=396).

3.1.2 Analysis of Design Patterns

To analyse design patterns of challenges, we explored precedents for OLT design pattern classification. Cha et. al's (2006) diagnosis of learning styles based on user interface behaviours provided a suitable foundation. We reasoned if these heuristics classified OLTs with enough specificity for a machine learning algorithm, they would serve as an effective foundation on which to hone our classification. These initial design pattern classifications were as follows:

1. Navigation Components
2. Community Support Component
3. Links to Additional Content
4. Text-Driven Component
5. Visually-Driven Component

To support these classification, we considered additional design "notions" (so named as they were insufficiently precise as to be design patterns, but more specific to our project than broader insights that usually result from RtF) discovered from stakeholder interviews (see Section 4.2). We reframed these notions as the classifications below:

6. Goal Orientation Component
7. Task-Based Structure
8. Code-Driven Component
9. Code Editing Component

These classifications were collated and coded as a reference table for clarity during comparison (see Table 5.3 in section 5.1). The codes were mapped to design patterns according to visual identification. Figure 3.3 below is an example of this process:

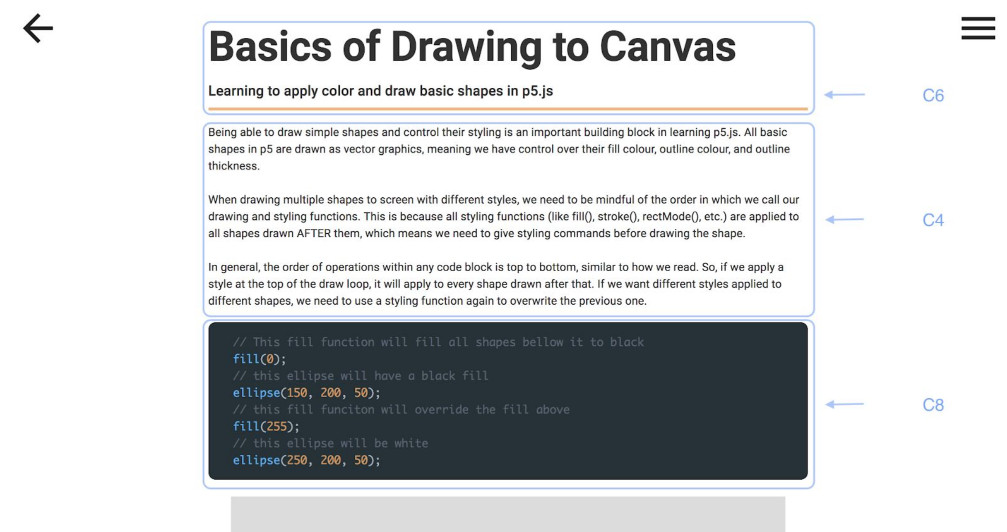

Figure 3.3: An example of design pattern classification

These classifications were weighted by challenges prevalence and analysed for association with encouragement state (see Table 5.3 in Section 5.1).

This prevalence of association established a general understanding of the effects of design patterns in challenges. To gain a deeper understanding of the nuances in the encouragement state when engaging with the design patterns, we conducted semi structured interviews in Phase 2.

3.2 Phase 2 Evaluation: Semester 1 Student Interviews

In Phase 2, we interviewed Design Programming students in Semester One of 2020. The goal of Phase 2 was to complement Exploratory Data Analysis with qualitative data analysis which is useful for "working out how the things that people do make sense from their perspective" (Ezzy, 2013). In the context of our research, these perspectives revealed the nuances of the relationship between design patterns and the encouragement state: a broad term for experiences that encourage an individual to cultivate learning motivation. As a collaborative research phase, tasks involved were completed as a team. The breakdown of tasks is detailed in Section 3.2.2.

Semi structured interviews are a method of obtaining qualitative data. They are loosely structured to allow new ideas introduced by the interviewee to influence the direction of the interview. According to Longhurst (2003) "semi structured interviews unfold in a conversational manner offering participants the chance to explore issues they feel are important". These important ideas were the nuances we wished to reveal. They complement exploratory data analysis to highlight the most important design pattern encouragement state relationships discovered in quantitative data analysis (see Section 3.2). Thematic analysis was the process used to do this.

Thematic analysis (TA) identifies and interprets patterns or 'themes' in a set of qualitative data. According to Braun and Clarke (2012), "TA allows the researcher to see and make sense of collective or shared meaning and experiences." Through thematic analysis of semi structured interviews in the larger RtD process, we highlighted the important design pattern encouragement state relationships to create a foundation of assumptions for how our design prototypes ought to manifest in order to attain our design goals; as challenges that encourage the cultivation of learning motivation through the engagement of effective design patterns.

3.2.1 Participants

Participants were selected from the Design Programming cohort. These were first year students from a variety of degrees that offered design programming as a course. A study in the UK found that first year university students (n=4,699) tend to develop heightened levels of anxiety (Cooke et al., 2006). A study from Brisbane of first year students (n=347) found "students with an Orientation to the Future were more likely than other students to report higher levels of Academic Application and Academic Orientation" (Horstmanshof & Zimitat, 2007). These ideas of anxiety and future orientation were considered during the analysis of interviews and their implications noted (see Section 6.2).

3.2.2 Interview Structure

Interviews sessions were split between two researchers (myself and another honours student) who then transcribed these individually. Transcriptions were separated into quotes and coded individually before comparing and reaching code consensus collaboratively. The semi structured interviews in Phase 2 were conducted in two rounds. The first round was conducted during the earlier weeks of semester 1 2020. The second round in the later weeks of semester 1 2020. The first round explored general sentiment towards the course as well as first impressions of design patterns in the eLearning platform and challenges. Prompt points were used as the set of questions that provided the semi-structure of these interviews and can be found in Section 9.1. A part of these prompt points was referring to an individual data from Phase 1 as a method of focusing nuanced questions on specific data regarding a student's encouragement state when experiencing challenges.

Because time had passed and students gained more familiarity with the platform, the second round explored how the experience of the course compared with student expectations, the social dynamics of the course and their evaluations of what makes a good challenge, with discussion about specific challenges student thought did and did not achieve this. Prompt points were used again in this round and can be found in Section 9.2.

From the perspective of this research, the aim of separation through rounds was to gain a greater understanding of the timeless aspects that affect the relationship between design patterns and the encouragement state. Thematic analysis was used to determine the timelessness, and therefore importance, of these patterns i.e. themes. As well as determination of timeless themes, this analysis informed the further design of technological artefacts (see Section 4.3).

3.2.3 Thematic Analysis

Thematic analysis was conducted to identify themes and weigh their importance based on their prevalence in the dataset. This process was a modification of the coding reliability approach (Boyatzis, 1998) whilst considering the criticisms of this method (Terry et al., 2017),(Braun & Clarke, 2012) and subsequent suggestion of the reflexive approach (Braun & Clarke, 2013).

The coding reliability approach consists of the following three principles. The first principle is the use of a structured and fixed code book. A fixed code book means raters do not create new codes even if they feel restricted by the code book. This was a main critique of Braun and Clarke (2012). The second principle is multiple coders independently apply the code book to the data. This is accepted as the core benefit of TA from its critics, as it avoids rater bias (Terry et al., 2017). The third principle is the measurement of inter-rater reliability using Cohen's Kappa (Cohen, 1960). Cohen's Kappa measures the agreement between two raters who classify N items into C mutually exclusive categories.

Braun & Clarke (2012) critique the dependency of the coding reliability method on Cohen's Kappa due to the resulting emphasis on code consensus between codes rather than on the emergence of ideas. This difference denotes the difference between the code reliability approach and the reflexive approach (2013). Our interpretation of TA was conducted as follows:

The recorded interviews were transcribed and divided into quotes. The aim during division was to maintain quotes brevity whilst providing context. Based on the reflexive approach, we used an *unfixed* code bank as per the reflexive approach.

After independent development, the two researchers compared codes to reach approximate consensus. In cases where there was disagreement or an agreement of both perspectives, two codes were used for a single item. These codes were then structured in a pivot table and weighted by prevalence to establish findings (see Section 5.2). After coding, the two researchers worked separately, organising the codes into themes based on their separate research questions.

Due to the separation between round one and two, the codes established in round one grounded the round two coding. Codes were weighted by prevalence. This weighing process quantified thematic prevalence in the dataset. Findings emerged by grouping weighted themes into aspects (of notions) and then into notions themselves. This process is an interpretation of the grouping techniques in the reflexive approach to thematic analysis (Braun & Clarke, 2013). The results are recorded in Section 5.2. These findings, in the form of the four design notions, significantly influenced the conceptual redesign of our technological artefacts (see Section 4.3).

3.3 Phase 3 Evaluation: Focus Groups

After the development of our meta-design prototype (see Section 4.5) Phase 3 employed focus groups as a validation method. As an individual research phase, this was conducted alone as the results pertain solely to the objectives of this research. The goal of Phase 3 was to better understand how meta-design can effectively guide the student-authorship of challenges. This had two aspects: how students approach designing challenges and whether a meta-design framework makes this a more enjoyable and effective learning experience. In studying meta-design, we needed to orient ourselves to it's novelty and understand the environmental values involved e.g. social dynamics and student self assessment. Focus groups are recommended to researchers orienting themselves to a new field (Longhurst, 2003). Focus groups have also been used effectively in the study of environmental values (Burgess, Limb & Harrison, 1988). The previous effectiveness of focus groups in studying new environments suitability for Phase 3.

Like semi structured interviews, focus groups are conversational and informal in tone. Honeyfield's research (1999) on the masculine representation in television suggests this informality combined with a common context are factors that contribute to a compatible focus group environment. The common context in our research environment was a cohort planning for the same assessment. Because of the prevalence of notions concerning student self assessment and social parameters in results of Phase 2 (see Section 6.2.1), we hypothesised the integration of a meta-design framework would yield a positive increase in motivation as well as both perceived and actual efficacy. The focus groups were the first evaluation phase to confirm or deny this hypothesis.

3.3.1 Focus Group Structure

To establish a sense of informality our focus groups were presented through slack, a more conversational and informal messaging online communication system. The benefit of using this communication method was a simple administration of group allocation via slack emojis. Each group was allocated an emoji. To promote a lack of perceived hierarchy between focus groups, emojis chosen were based around a hierarchy neutral theme: different sports. Figure 3.5 below illustrates the use of this method.

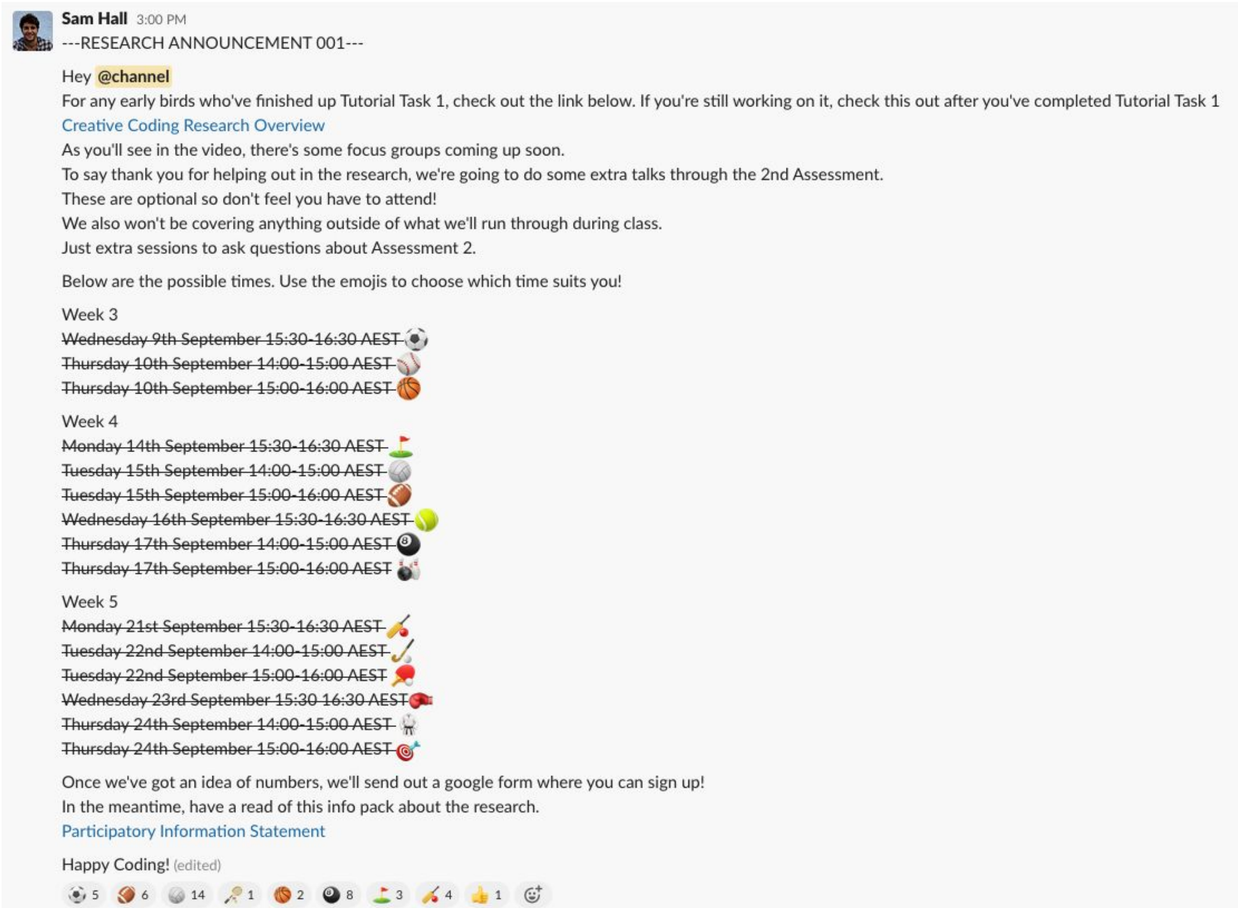

Figure 3.5: A use of slack emojis to promote informal focus group events.

Various times were offered and conducted based on demand. As thanks for their attendance, the first part of the sessions would be an assessment workshop to assist students with their assignments. This assessment workshop also provided an opportunity to implicitly explore research objectives. The sessions were 45 minutes and split into three sections. These were going through the recipe, a Q and A and the Focus Group. Figure 3.6 shows a screenshot of an orientation video provided to students that defines these parts.

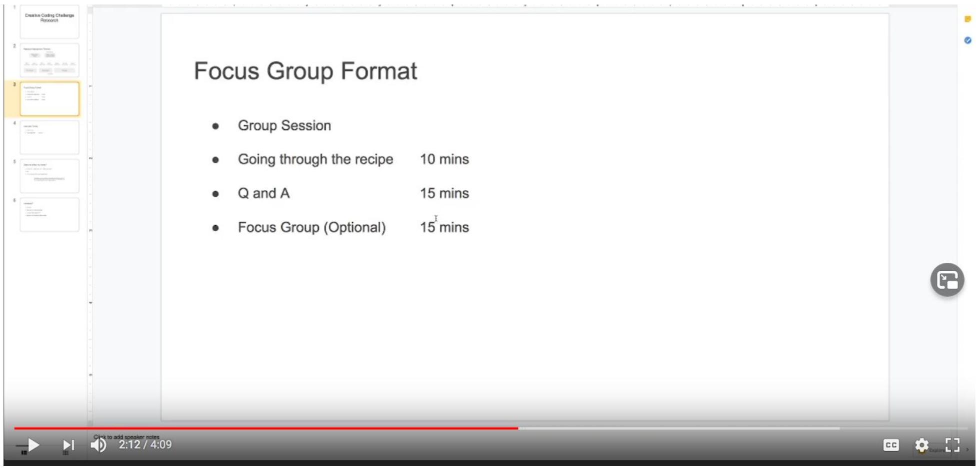

Figure 3.6: A section of the focus group orientation video provided to students.

Like semi structured interviews, both focus groups were based on a set of prompt points (see Figure 9.9 in the Appendix).

The overview was structured depending on the familiarity of the group with the Assessment Guide. Either the facilitator or students who felt confident would lead the discussion in this section. The Q and A explored questions and answers more specific to issues students encountered during design and development of student-made challenges. The group was encouraged to answer each other's questions and was guided by the facilitator when conversation did not arise organically. At this point, students were reminded that the workshop had concluded and the final section would be more abstract and less about specific assignments. The aim of the Focus Group section was to more explicitly explore research objectives. The data from recorded sessions was transcribed, coded and weighted by prevalence through a process of thematic analysis.

An unintended consequence of these Focus Groups was providing students with a workshop to allow the instructional strategy of their challenges to be cultivated and better communicated through design patterns. This is covered in further detail in the discussion (see Section 6.3.2)

3.3.2 Thematic Analysis

Differences arose between the thematic analysis of focus groups and semi structured interviews. In Phase 3, codes were attributed to groups instead of individuals. This was due to the inherent bias of individuals in a focus group and that the effective understanding of focus group themes is derived from a group perspective (Longhurst, 2003). Unlike Phase 1 and 2 which were part of the larger Creative Coding Challenges research, Phase 3 was specific to this honours project. Subsequently, item categories were only coded by one researcher. To offset the inherent bias, notions discovered in Phase 3 were compared with those discovered in Phase 2. This gave us a deeper understanding of theme importance in both Phase 2 and Phase 3 findings by observing the correlation of findings in instances where research objectives overlapped between the two phases (see Section 5.3).

Themes were weighted by prevalence and grouped into aspects and notions. Results of this can be found in Section 5.3. These aspects and notions deepened our understanding of how students approach designing challenges (see Section 6.2), how a meta-design framework makes this a more enjoyable and effective learning experience (see Section 6.3) and, through a RtD process, validated the effectiveness of our meta-design prototype in terms of the encouragement state (see Section 6.3) . The validation of the effectiveness of our meta-design prototype improving student achievement is explored in Phase 5 (see Section 3.5).

3.4 Phase 4 Evaluation: Semester 2 Student Interviews

The goal of Phase 4 was to deepen our understanding of the relationship between design patterns and the encouragement state as well as validate the effectiveness of the redesigned eLearning platform in terms of this understanding. Semi structured interviews were thematically analysed to reveal findings. As a collaborative research phase, tasks involved were completed as a team. The breakdown of tasks is detailed in Section 3.4.2. By comparing the findings of phases 2 and 4, we observed the difference and similarities in theme prevalence between experiences before and after platform redesign. These differences and similarities revealed what aspects of the encouragement state were affected by eLearning platform design patterns and what aspects were affected by challenge design patterns (see Section 6.1.7).

3.4.1 Participants

The participants in Phase 4 were selected from the semester two 2020 Design Programming cohort. These were postgraduate students studying a Master's of Interaction Design. A study at Curtin University found that postgraduate students had a higher self assessment of digital literacy skills in comparison with undergraduates (Conway, 2011). This was considered in the evaluation of findings (see Section 5.2).

3.4.2 Interview Structure

Interviews sessions were again split between the two student researchers who then transcribed these individually. Transcriptions were again separated into quotes and then and coded individually before comparing and reaching code consensus collaboratively. Phase 4 had one round of semi structured interviews. These were conducted during semester 2 of 2020. We explored general sentiment towards the course as well as first impressions of design patterns in the eLearning platform and challenges. Prompt points were used as the set of questions that provided the semi-structure of these interviews and can be found in Section 9.1.

We explored a combination of aspects discovered in Phase 2, using similar prompts points (see Section 9.4) to guide conversation towards insights that would demonstrate the important values from the student perspective of these aspects. The aim of this exploration was to observe the effect of the redesigned platform on student encouragement state and deepen our understanding of the design pattern encouraging state relationship as a result. To observe this effect, Phase 4 findings were thematically analysed and weighted by prevalence.

3.4.3 Thematic Analysis

The thematic analysis method was used to discover underlying ideas as well as explore differences with the interviews in Phase 2 (see Section 3.2). Transcripts were coded using existing codes from Phase 2 as a guide. For quotes that didn't fit these codes, new codes were created as per the reflexive method (Braun & Clarke, 2013). Thematic Codes were weighted by prevalence and grouped into aspects and notions. We believe the differences between Phase 2 and Phase 4 prevalence that emerged was due to the effects of the redesigned platform and the differences between undergraduate and postgraduate experiences of design programming. Findings were recorded in the results (see Section 5.3) and the implications of these differences noted in the discussion (see Section 6.1).

3.5 Phase 5 Evaluation: Student-made Challenge Analysis

The goal of Phase 5 was to conduct heuristic evaluations and analysis of quantitative data to validate the effectiveness of our meta-design prototype. Students had created their own challenges using our framework as an assessable activity in another course, and the purpose of this activity was to assess the framework via their creations. As an individual research phase, this was conducted individually as the results pertained to the objectives of this research. This evaluation deepened our understanding of how meta-design can effectively guide the design of student-made challenges. In the context of the artificial sciences, A heuristic evaluation is an evaluation of usability. By comparing an artefact against a set of recognised usability principles, it can be validated from a qualitative perspective (Nielsen & Molich, 1990). We evaluated our meta-design prototype for its capacity to inform student led teaching, using a combination of recognised heuristics applied to the student-created content.

3.5.1 Heuristic Evaluation Structure

Our quantitative analysis began as a consideration of Neilsen's heuristics for user-interface design. (Nielsen, 1994). Because of its roots in engineering, these heuristics provided a functional foundation on which to define effective student-made challenges and therefore, the effectiveness of our meta-design prototype.

To complement this emphasis functional efficiency, we considered Gerhardt-Powals' cognitive engineering principles (1996). These principles are focused on the cognitive performance of the users. We combined these general heuristics with the prevalent notions discovered through semi structured interviews of phases 2 and 4. This combination provided heuristics that were not only recognised but collectively defined by users through thematic analysis. Experts used these heuristics to evaluate randomly selected challenges with a score of at least 90% in assessment marks. Half the sample were student-made challenges created with meta-design, the other half created without from a previous cohort. The responses to these heuristics were analysed and are recorded in results (see Section 5.4.1). From this analysis, we gained a deeper understanding of the ways in which meta-design can effectively guide the design of student-made challenges.

3.5.2 Quantitative Analysis Structure

To gain a more holistic view of the effectiveness of our meta-design prototype as a guide for students as they made challenges, we compared all assessment marks from the previous cohort with the equivalent marks of this cohort (see Section 5.4). This comparison provided insights into the mechanics of mark ratios with the introduction of a meta-design (see Section 6.3). While not an independent factor, this analysis of mark distribution combined the heuristic evaluation to further deepen our understanding of the ways in which meta-design can effectively guide the design of student-made challenges.

Chapter 4

Design Process

We understand Herb Simon's two principle outputs of the artificial sciences as scientific knowledge and design. Scientific knowledge is the understanding of the simplicity of the patterns inherent in the complex chaos of the natural world. Design is the understanding of the way "things ought to be in in order to attain goals" (1996). Where Chapter 3 of this research is concerned with the methods involved in the refinement of scientific knowledge involved in our research objectives, Chapter 4 explores the understanding gained when considering how the technological artefacts of our research *ought* to be to attain our research objectives.

Zimmerman interprets Research through Design as activity guided by the design process, building an environment using heuristics through which effective analysis can take place. To ground this idea, our design process recognises Banathy's dynamics of divergence and convergence (1996) as a framework in accordance with Research through Design. Figure 4.1 below illustrates the interplay of these dynamics.

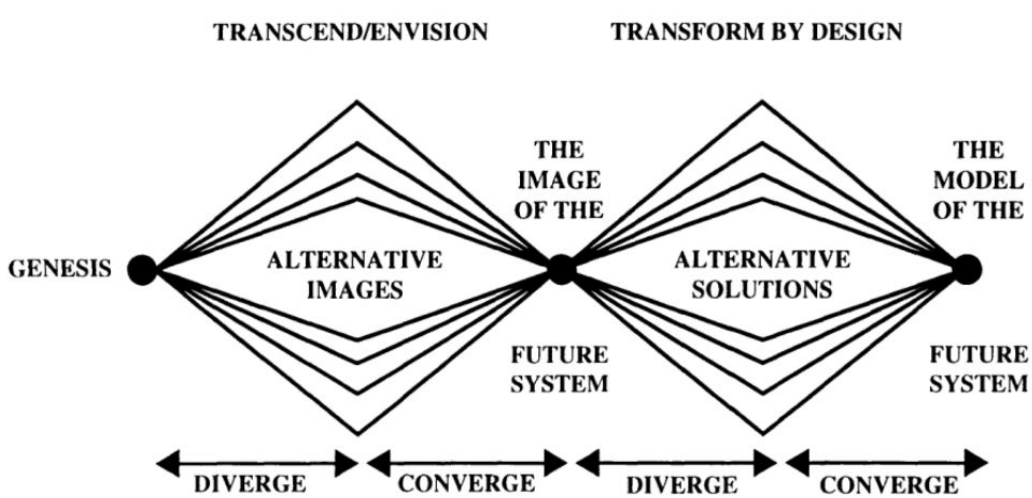

Figure 4.1: Banathy's dynamics of divergence and convergence (1996)

Figure 4.2 below demonstrates our interpretation of this Banathy's dynamics as it manifested through our research.

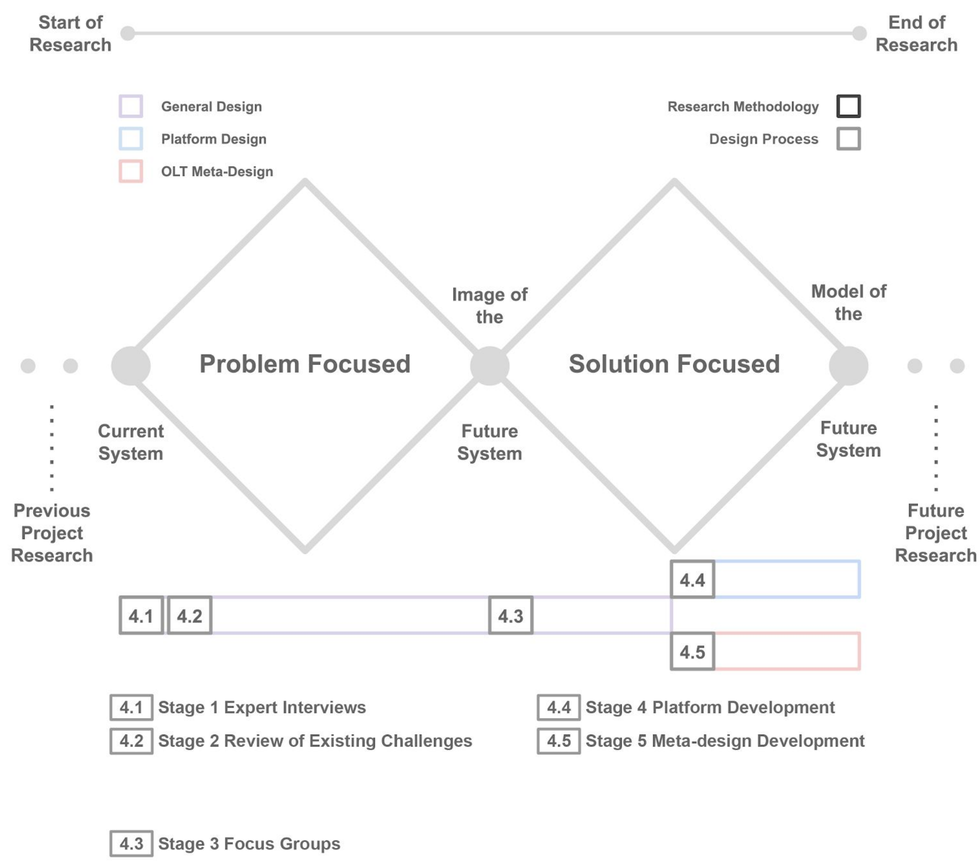

Figure 4.2: Our interpretation of Banathy's dynamics as a guide for our design process in context.

To better explore Banathy's dynamics of divergence and convergence, our design process had two focuses: one problem focused and the other solution focused. The former is a manifestation of Banathy's process of transcendence towards the image of the future system (1996) i.e. our technological artefacts. The aim of which was to build a research environment quickly based on available data to ground research analysis and effectively design. The latter is a manifestation of the process of transformation towards the model of the future system. The aim of which is to design effective artifacts based on the findings from the research analysis. The subsequent analysis of these artifacts deepened our understanding of research objectives (see Section 1.2). This process emulates Simon's principles of scientific knowledge and design (1996).

We began the design process with expert interviews in Stage 1. Informal interviews with these stakeholders provided a background of aspects outside our research objectives present in the learning experience that could contribute to the research environment (see Section 4.1). We built preliminary design prototypes based on a review of existing OLTs in Stage 2 (see Section 4.2). These prototypes were built efficiently based on available data as a means to create a research environment through which research analysis in Phases 1 and 2 could be conducted (see Sections 3.1 and 3.2). The insights from findings of this analysis (see Sections 5.1 and 5.2) provided a foundation of user needs and design heuristics to effectively create informed design concepts in Stage 3 (see Section 4.3).

Design prototypes were built in Stages 4 and 5. Stage 4 (see Section 4.4) consisted of designing and developing a new eLearning platform for Design Programming. This new platform was based on analysis from Phases 1 and 2 of research. Results and subsequent insights related to the eLearning platform were part of the larger research project and not included in our objectives. Stage 5 (see Section 4.5) was the design and development of a meta-design framework for student-made challenge creation. The framework was designed as an assessment guide. However, through analysis of results from Phase 3 it was discovered the facilitated workshops became an integral aspect of this framework (see Section 6.3.2).

The design prototypes were evaluated from a usability perspective in Phases 3, 4 and 5 of research (see Sections 3.3, 3.4 and 3.5) to evaluate prototype effectiveness and deepen understanding of research objectives. The sections in this chapter detail the phases of validation in this research which collectively form the design process.

4.1 Stage 1: Expert Interviews

To begin the process of divergence, we explored the context of the courses the elearning platform was integrated with. To compliment the perspective of the student explored in the research methodology (see Chapter 3), we conducted interviews with other notable stakeholders in the creative coding environment. These stakeholders were tutors and coordinators. The aim was to test questions for Phase 2 of research and understanding the tutor perspective to gain contextual knowledge in preparation for Stage 3 (see Section 4.3). These interviews were informally conducted, and included members of the broader project's research team. They're considered to be part of the stakeholder research component of our design process, interviews involved in research (see Sections 3.2 and 3.4)

Interviews with experts were conducted to gain an understanding of the tutors perspective of the learning experience. These are part of the design process as the tutor's perspective provides design insights based on their experience. As conversations diverted from practices Phase 2 questions, they included aspects of teaching resources, class schedule and a general overview of what tutors see as areas for improvement across the design programming as a course. This provided a foundation for understanding of the context behind the course, eLearning platform and challenges.. They also prepared us for potential affordances to consider as part of the conceptual design in Stage 3 (see Section 4.3).

4.1.1 Interview Structure

As a derivation of the semi structured interview method (Longhurst, 2003), three semi structured interviews took place each consisting of 15 minute sessions. These interviews gave us an opportunity to test and refine our delivery of the interview prompt points for Phase 2 of Research (see Section 3.2) Section 9.1 details these prompts points. These interviews were then analysed to build a foundation of insights for conceptual design in Stage 3 (see Section 4.3).

4.1.2 Insights

The conversations informed our initial understanding of the ideal creative coding challenge. This was based off the collective experience discussed with experts. The traits of the initial ideal OLT are listed below:

- *Students need to be able to intuitively navigate the OLT*
- *Students need to be able to get help when they need it*
- *Students need to be directed to material that can help them complete OLTs BEFORE they go the teacher or peer support*
- *Students need to get a bit of context about the code through regular text before being chucked into the code*
- *Students need a visual example of what they're aiming for. If they're making something animated, they need an animated example.*

- *Students needs to know what their goal of this OLT is as quickly as possible when they start*
- *Students need to be given OLTs as a task so they know when they've succeeded*
- *Students need to see pseudo code or a code snippet broken down in normal text via code comments*
- *Students need to actually code something in the OLT. It needs to suit the complexity needs to suit ALL the combined knowledge provided from the components on the OLT or explicitly required from additional links*

These traits provided a list of informal heuristics through which we could review existing OLTs created by students for the platform (see Section 4.2). We could also observe the validity of these heuristics when applied to a large sample of OLTs and how they manifest in design patterns.

These interviews revealed the need to group OLTs by objective. These objectives were based on the needs of the student as they became more proficient in their understanding of JavaScript concepts or syntax e.g. for Loops or Arrays. The four groups were defined as follows: Introductory, Exploratory, Advanced and Creative. These categories were later iterated according to platform affordances and conceptual design (see Section 4.3).

4.2 Stage 2: Review of Existing Challenges

Building on informal heuristics from expert interviews, a review of existing OLTs was conducted. The aim was to gain a contextual understanding of student-made challenges. This provided preliminary contextual for our second research objective: understanding how students design learning activities, particularly online creative coding tasks.

We analysed marking data from the challenges students had created during Assessment 1 of Web Design and Technologies in Semester 2 of 2019. We limited reviewed challenges to those marked at 95% or above to ensure a high quality of challenges. They were divided amongst researchers and reviewed individually. By comparing comments left during review with informal heuristics outlined in Section 4.1, we could determine the validity of these heuristics in a practical context and the general level of challenge quality.

Figure 4.3 below illustrates the review comments as given by the research team.

Topic	Type	Good candidate?	Positive	Negative	Potential Tags
Loops	Introductory	☐		This is a good tutorial, but needs to be	
Transformations	Exploratory	☐	Exercises too complex		
functions	Introductory	☑	great recursion syntax		characters, complex
random function	Introductory	☑	parameters up the top is nice for function based tutorials		
Perlin	Introductory	☑	nice illustration of the difference between perlin noise		walker
map function		☐	problem focused explanation of map function	not much setup with the example. need to	mouseX, mouseY
conditionals		☐		too complex and broad. needs to be more	
For loops		☐		not adding anything new..	
Noise	Introductory	☑	"how code takes a different path" great opening	doesnt explain boolean concept	Writing Style, concept
Key functions	Introductory	☑	fun exercise to play with	the image for first task seems interactive	game
Mouse Functions	Introductory	☑	Great introduction, great use of exercises and they		
Conditionals	Introductory	☑	A great, well thought out tutorial that incorporates		
3D Heightmap	Exploratory	☑	Best for advanced students. A detailed and well		
Loops & Conditionals	Introductory	☑	The content is quite dense and covers a lot but in a clear		
Functions	Introductory	☐	Good introduction for people who are very beginners	but not engaging enough	
Functions	Introductory	☐		Too basic, needs more substance	
Loops	Introductory	☐		Exercises were distracting and lost focus	
For Loops	Introductory	☑	Simple Structure, explains what for loops are for, why to	wriiting was a bit sloppy but can be built	Simple
Variables	Introductory	☑	The writing style is quite engaging. I like the		Writing Style
For Loops	Introductory	☑	having the examples of for loop and copy paste alt. right	the exercises are random and don't really	comparison
Functions	Introductory	☑	cool annotated picture of a function		infovis
OOP & Animation	Exploratory	☑	Really detailed, and has a mixture of simple and		
Colour	Introductory	☑	At times confusing and hard to follow		
Easing	Exploratory	☑	Very specific tutorial with great interactive		
For Loops	Introductory	☑	Less Exercises than the first but I like the walk through	Wasn't engaged in the writing style	Rhetorical Q
For loops	Introductory	☑	like the "loops inside loops" line		
Map() Function	Introductory	☑	Content is highly interactive and engaging,		

Figure 4.3: Feedback on OLTs from the research team.

The OLTs followed a template provided by the course coordinator of Web Design and Technologies, providing students with code components to manipulate and use effectively instead of starting from a blank document. Figure 4.4 below shows the template that had been provided to students in Semester 2 2019.

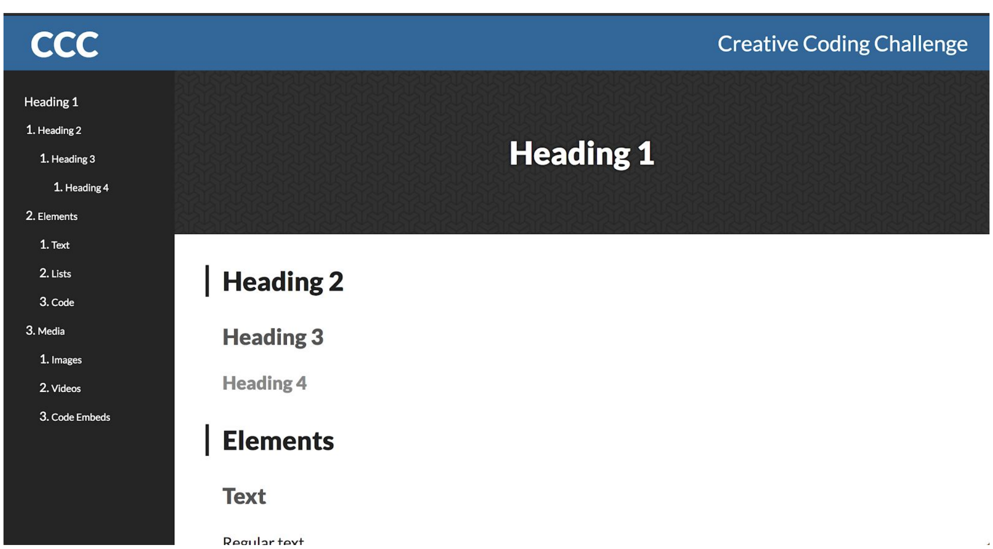

Figure 4.4: Template Provided for Student made OLTs (2019 version - before this research).

The research team collectively chose challenges based on their alignment with the informal heuristics defined in expert interviews (see Section 4.1) and categorised them according to concepts covered. The chosen OLTs were added to storyblok the content management system (CMS) for the eLearning platform. This CMS had been established during previous years of the larger research project. The CMS was designed to be simple yet flexible to allow the efficient addition of new content through a Graphical User Interface that let the research team choose from predefined design patterns: A title, subtitle, text box, pseudo-code box, code editor, image box and lists. Figure 4.5 below demonstrates these design patterns used in context.

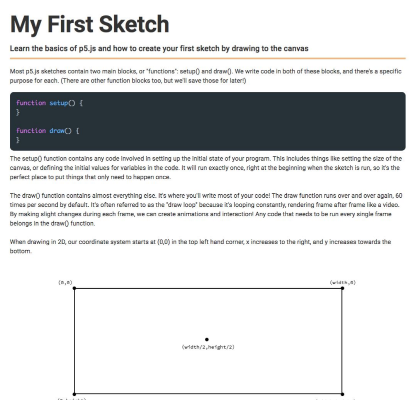

Figure 4.5: Design Patterns used in the context of a challenge.

4.3 Stage 3: Conceptual Design of eLearning

In Stage 3, the research team collaboratively formed the concepts for how the CCC Platform was to be designed. The initial task was establishing a timeline for development to account for affordances and responsibilities. Figure 4.6 below details a weekly task list from conceptual design to launch of developed prototypes.

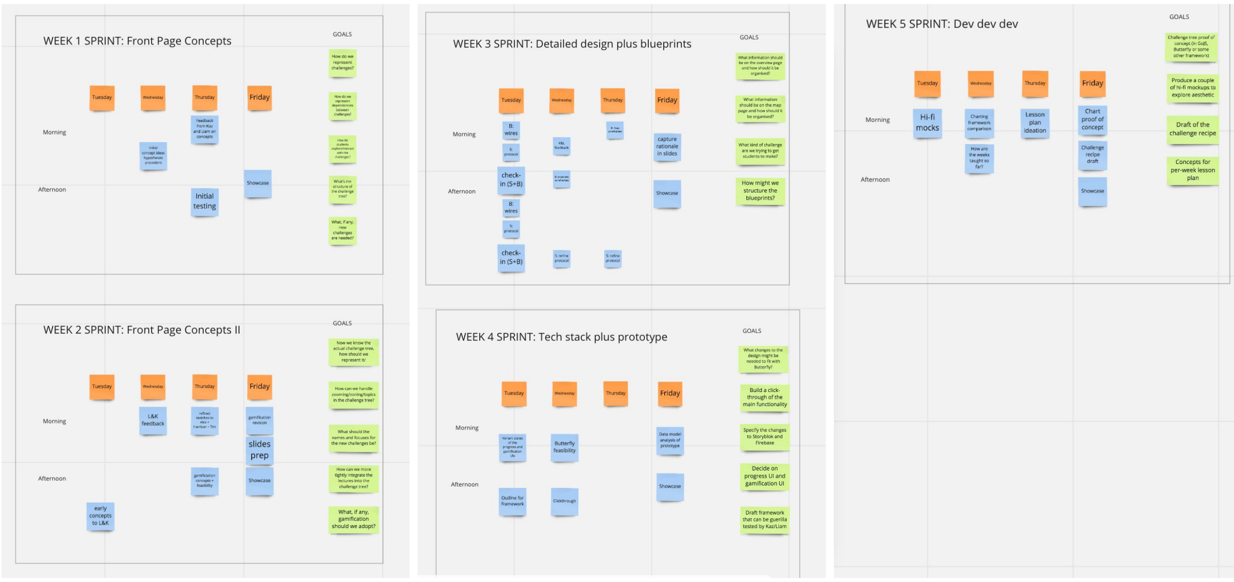

Figure 4.6: Weekly Task List from conceptual design to development.

Each week of this process started and ended with a research team meeting. In the earlier weeks, researchers prepared case studies accompanied by sketches and mockups. The fidelity of these would depend on the level of abstraction a concept design had progressed. The merits of a solution were determined through a balance of design needs and technical affordances.

Over time, the solutions manifested as two distinct prototypes. The first was a redesigned eLearning platform through which students could intuitively navigate between teaching resources this prototype was created together as a research team. The redesign was an equally shared effort between the author and another honours student. The second was a meta-design framework to guide students in creating challenges, the best of which would become part of the redesigned eLearning platform. This second prototype was created individually without the research team. Section 4.3 details the process leading to these final design prototypes, bridging the gap between discovered user needs and design solutions via conceptual design.

4.3.1 Platform Design

Our findings suggested users need a way to navigate the complexity of the creative coding eLearning platform and understand the context of challenges before they begin an OLT (see Section 5.2). Figure 4.6 below illustrates the platform view before redesign.

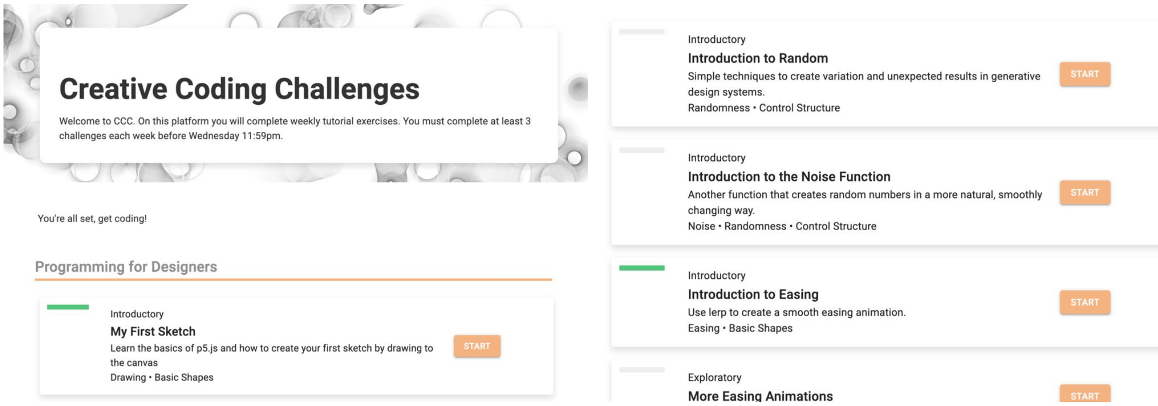

Figure 4.6: The 2019 eLearning design patterns prior to redesign

To solve this, we considered the hypertree, a precedent for complex systems navigation in virtual hyperbolic space. A hypertree is a display method for hierarchical data that has significant advantages over the display of data in a binary tree format. Advantages of space and focus have been defined through the differences in linear and radial nodes and the differences in hyperbolic and euclidean space (Lamping, Rao & Pirolli, 1995).

Consider an example of linear nodes i.e a simple binary tree. When the number of levels in a network is ‘n’ the width of a screen equals 2^n (e.g. 4 levels would require 16 units of space in width).

screen width of linear nodes = 2^n

Whereas through radial nodes, when the number of levels in a network is ‘n’, the width of a screen equals 2(n-1)+1 (e.g. 4 levels would require 7 units of space). Figure 4.7 below illustrates this difference.

screen width of radial nodes = 2(n-)+1

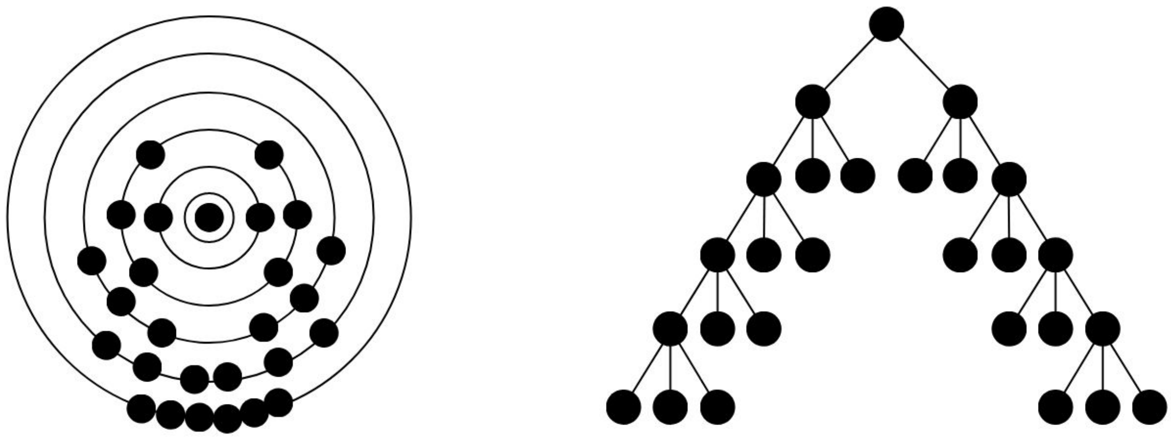

Figure 4.7: The Difference between linear and radial nodes (Fred, 2014)

The hyperbolic tree places radial nodes in a hyperbolic space. The positive curvature of hyperbolic space adds space and focus to a two dimensional euclidean space. This creates more space efficiency in a visualisation (1995). Figure 4.8 below illustrates the differences between radial nodes used in a hyperbolic euclidean spaces.

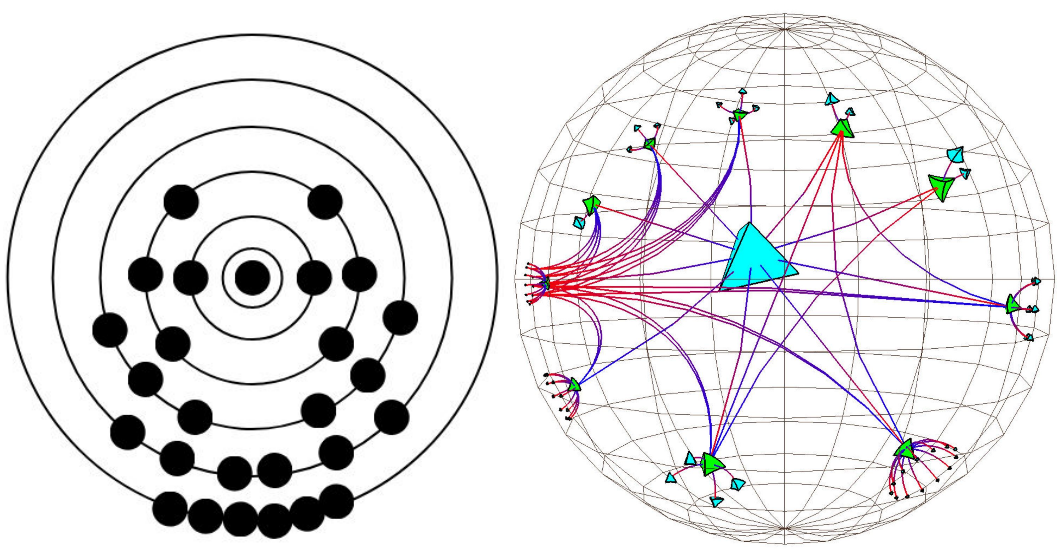

Figure 4.8: The Difference between euclidean and hyperbolic space

(Fred, 2014) (Munzner, 2000)

We saw this as a key advantage in a web app context. As the user focuses on the outermost nodes, the focal point of the screen changes, creating more space between the nodes closest to the mouse. OLTs could be visualised collectively and the relationship between knowledge visually defined without a cluttered experience. With a plan to supply such a large quantity of content on a single page, it was considered whether there needs to be a method to orient the user with challenge information. We considered two ways to do this. The first was using cards as a way to display challenge information. This card layout provided the opportunity to communicate challenge categories. Figure 4.9 below details the card layout from Google's Material Design Language (2020).

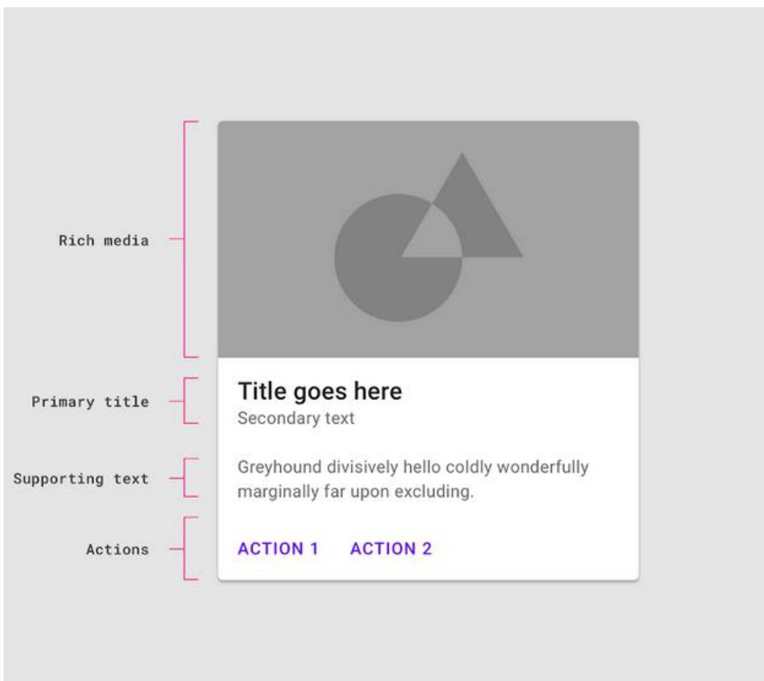

Figure 4.9: The Card Layout from Google's Material Design Language (2020).

The second was the display of time using a universal pattern for radial time display: a clock face. Figure 4.10 illustrates the abstract combination of a hypertree card clock face layout.

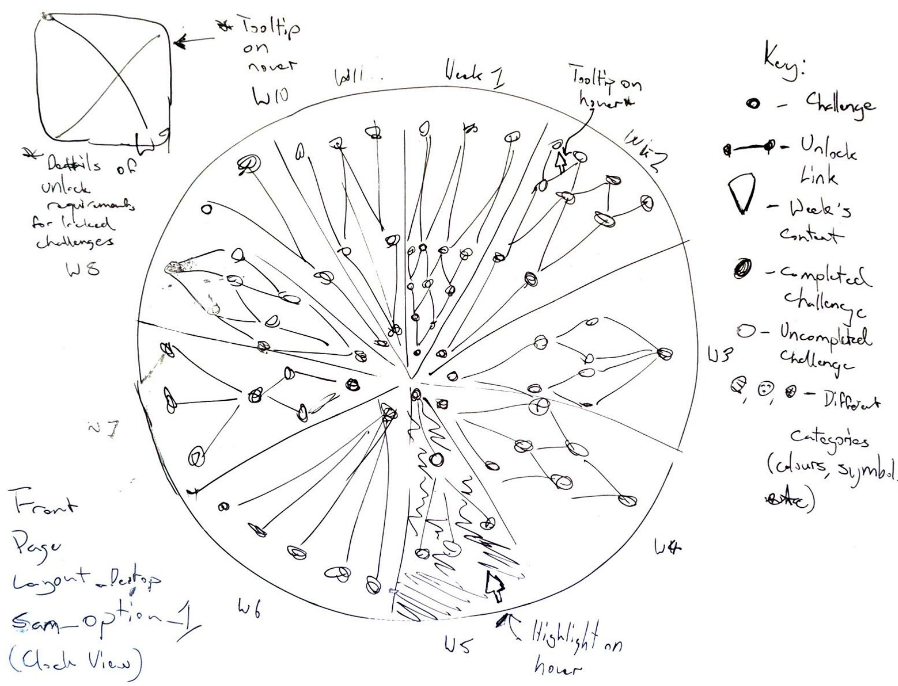

Figure 4.10: The Hypertree, Card and Clock Face layout.

The considered this a good option. However, it would require technical and design work beyond the time and resource constraints of the project. We reconsidered the idea of space and concluded that we needed to make users aware of time but not all challenges at once. Using the simpler tree layout achieved this. These layouts would each represent a week of OLTs for a user to complete, differentiated by category. Figure 4.11 below illustrates this concept.

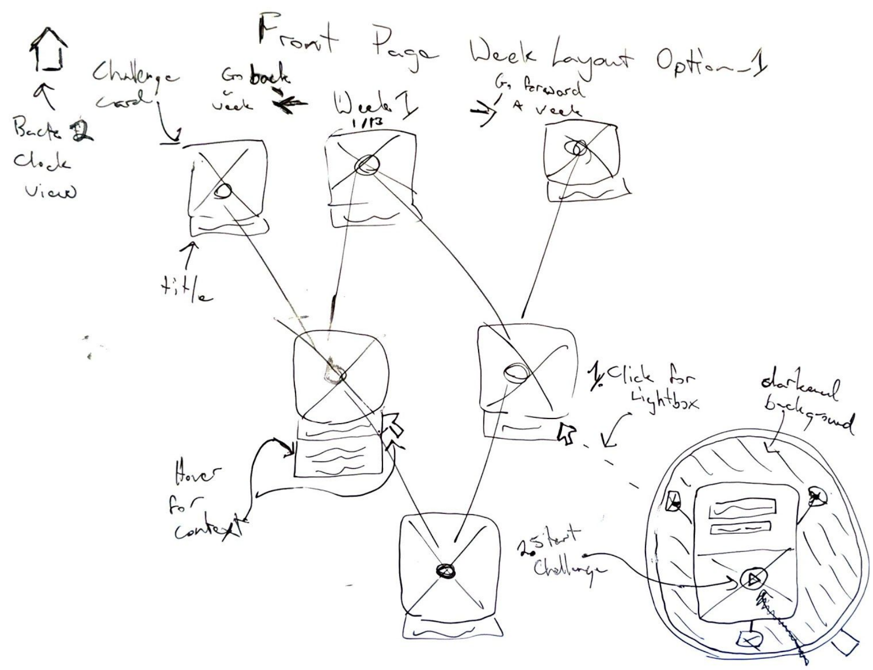

Figure 4.11: The Tree Layout.

The Tree Layout was pursued as a concept as it balanced user needs and technical affordances. Mockups began on this concept to consider how colour, copy, layout and interaction would be visualised to meet user needs and provide an intuitive user flow.

4.3.2 Feedback Design

Our findings also suggested users need a way to understand their progress in relation to what was expected and their position within the cohort (see Section 5.2). To achieve this, we focused on gamification as a precedent for engagement (Muntean, 2011). McGonigal proposes four defining traits of a game: Goals, Rules, Feedback System and Voluntary Participation (2011). McGonigal suggests an effective game is the ideal system of engagement as it encourages the gamer to complete unnecessarily complex tasks without purpose. While it could be said that it is the purposelessness of a game that makes it so engaging, we believed these aspects could be repurposed for situations with a purpose outside the task. In our context, this purpose is learning to code creatively. We found two of McGonigal's rules that could be integrated into an elearning system without radical change to content. These were inclusion of a feedback system and voluntary participation.

In the context of a challenge, a feedback system is a medium for a visualisation of the users acquisition of knowledge concerning an objective outcome. Some common forms of feedback systems are points, levels, a score or a progress bar (McGonigal, 2011). Figure 4.12 below illustrates the concepts sketches created to collectively discuss ideas. A technical limitation was the creation of more Application Programming Interfaces (APIs) to access data for metrics. This would require development work of an unknown time frame.

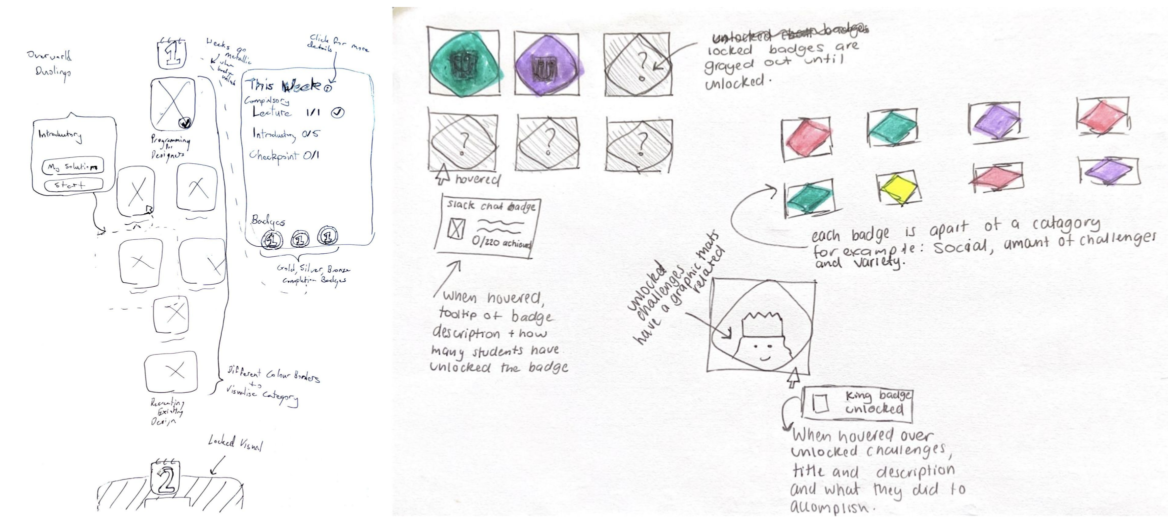

Figure 4.12

An aspect not reliant on technical affordances was voluntary participation. Voluntary participation is a willing acceptance of the paradigm in which a user becomes involved. Mcgonigal defines this as a requirement “that everyone who is playing the game knowingly and willingly accepts the goal, the rules, and the feedback” (2011). We conceptualised a category of challenge within the platform that was not required but was an exploratory challenge, a part of the platform to do for the sake of doing it. This began the reconfiguration of challenge categories: Required, Checkpoint Recommended and Lectures. Figure 4.13 below details sketches of this concept.

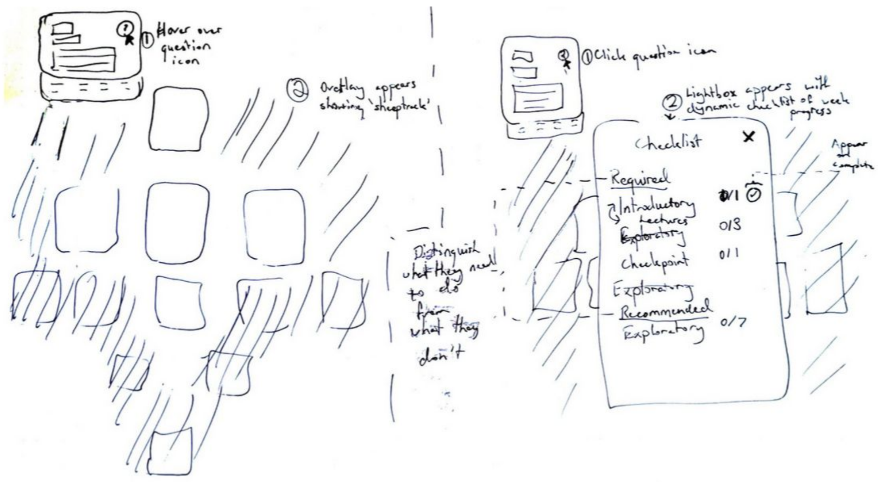

Figure 4.13: Voluntary Participation concept sketches for the eLearning platform.

4.3.3 Assessment Guide Design

During Stage 3, we noticed a lack of student-made challenges used in the eLearning platform. After discussion with the Research Team, it was discovered that the course coordinator of Design Programming believed the 2019 student-made challenges lacked pedagogical merit and were not used.

A design need emerged from this decision: There was a need to provide a relatable step by step experience in a pedagogically effective structure. We conceptualised a meta-design system (see Section 2.3) to accomplish this. Initially known as 'The protocol' our concept consisted of an index of documents for students to navigate that would provide conceptual tools through which they could craft pedagogically structured, relatable challenges. Figure 4.14 below details sketches of this concept.

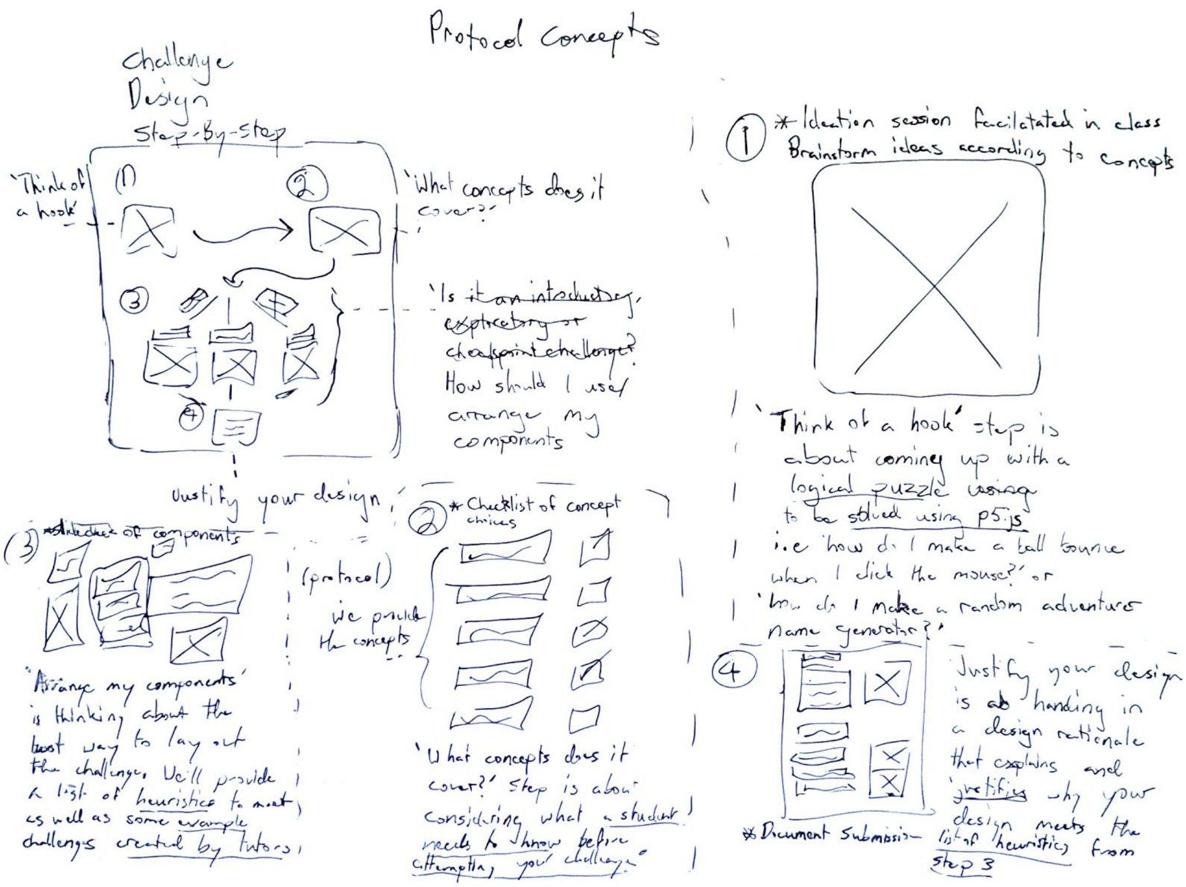

Figure 4.14: An index of conceptual tools for the meta-Design of student authored OLTs.

The research team considered navigating between conceptual tools a technical burden for users. To solve this, we combined these tools into a one document with links to external resources. The protocol became a recipe that students could use to 'cook up' a challenge by following a step-by-step guide. In further research it was discovered the metaphorical names were more confusing than helpful for students (see Section 6.3.1) so hereafter this design prototype will be referred to as an Assessment guide. We decided upon these following criteria as the basis of conceptual design.

- *A main document with links to external resources*
- *A task of understanding the effective use of design patterns to teach a code concept.*
- *The main objective is structure in discrete section each with a sub-task to complete before progressing to the next section*
- *Content generally based on the philosophy behind the instructional strategy of the main task.*
- *Content specifically based on the philosophy behind the instructional strategy of the sub-task.*

4.4 Stage 4: eLearning Platform Development

Platform design and development occurred in the last three weeks of the research team's development sprints between semesters. The larger project team was split into smaller design and development teams. The team in the design role spent the first week creating high fidelity versions of the concepts agreed upon, and the remaining two assisting the development team with design changes based on time and resource constraints.

The development team spent the first week considering existing programming frameworks, and the second and third designing the mockups created by the design making alterations according to time and resource constraints.

4.4.1 Mockups

The platform mockups needed to visualise the color, copy layout and interaction from conceptual platform design (see Sections 4.3.1 and 4.3.2) this was to ensure the design needs concepts were based on were met. Differences in potential user satisfaction between the tree layout and those that emerged from concept design such as the hypertree (see Section 4.3) were not large to justify the time resources requirements to build a hypertree.

The eLearning user interface was divided into the design of two 'views': an overview and a week view. Designs were structured this way to conform with the pre-existing structure of the eLearning platform. A major structural difference between existing eLearning design patterns and mockups were the addition of a week view and the lack of challenge visibility on the main page (see Figure 4.1.4). This was a simple alteration and aligned with results from thematic analysis as it would ease navigation stress from the overwhelming nature of seeing all the challenges upon arrival to the elearning platform (see Section 5.2). This was also supported by the expert interviews which highlighted a need for goal orientation. This is also a general idea supported by eLearning theory explored in the background (see Section 2.1.3).

The overview mockups consisted of cards in a grid, one for each week with badges to signify the completion progress. We used these design patterns in our mockups to allow users a simple way to navigate the complexity of the platform. Figure 4.15 illustrates a mockup of the overview layout.

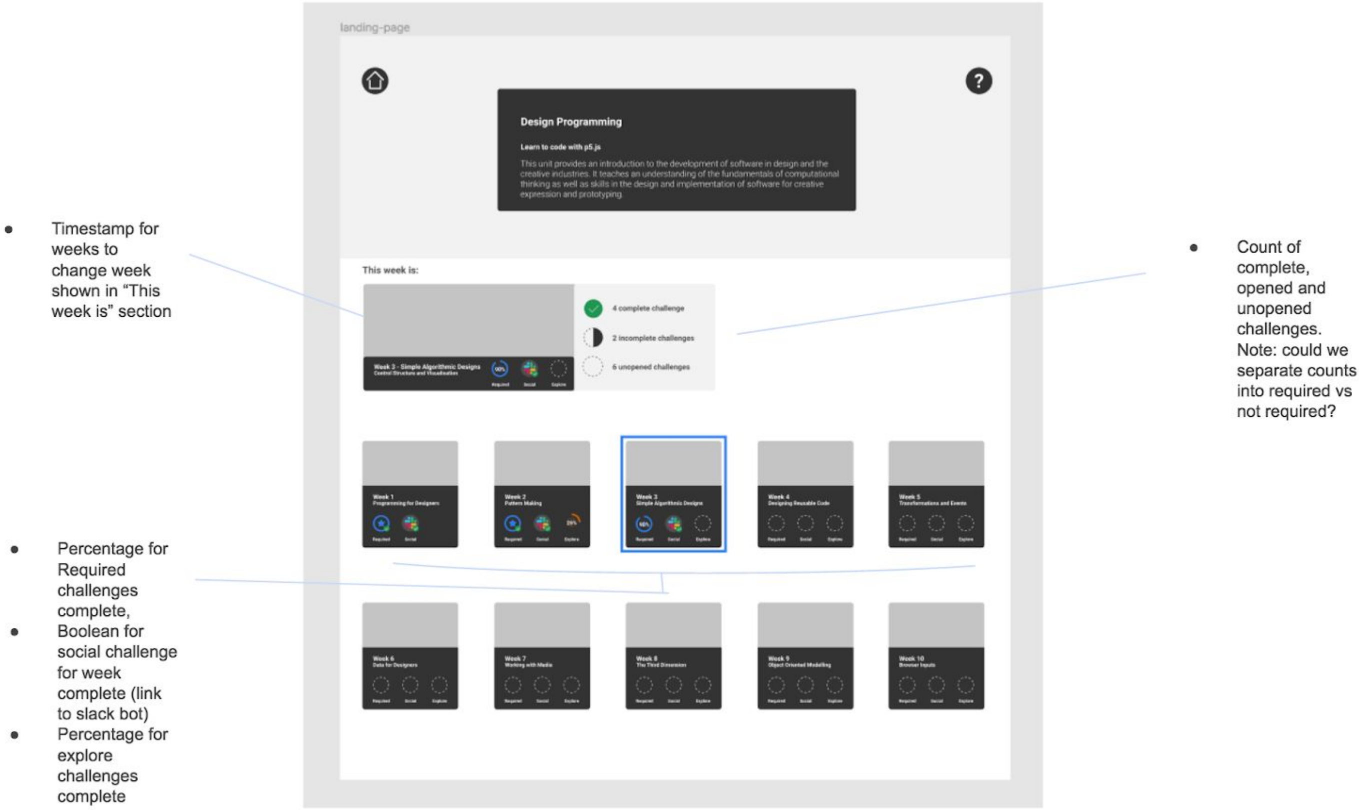

Figure 4.15: A mockup of the overview layout

As we opted for simplicity, the week view were linear nodes presented in two dimensional euclidean space. Challenge Categories were denoted by colour, badges for that week were displayed and cards represented unique challenges with an image and title. These mockups aimed to simplify the process of understanding the context of challenges before a user begins a challenge. Figure 4.16 below illustrates this week view.

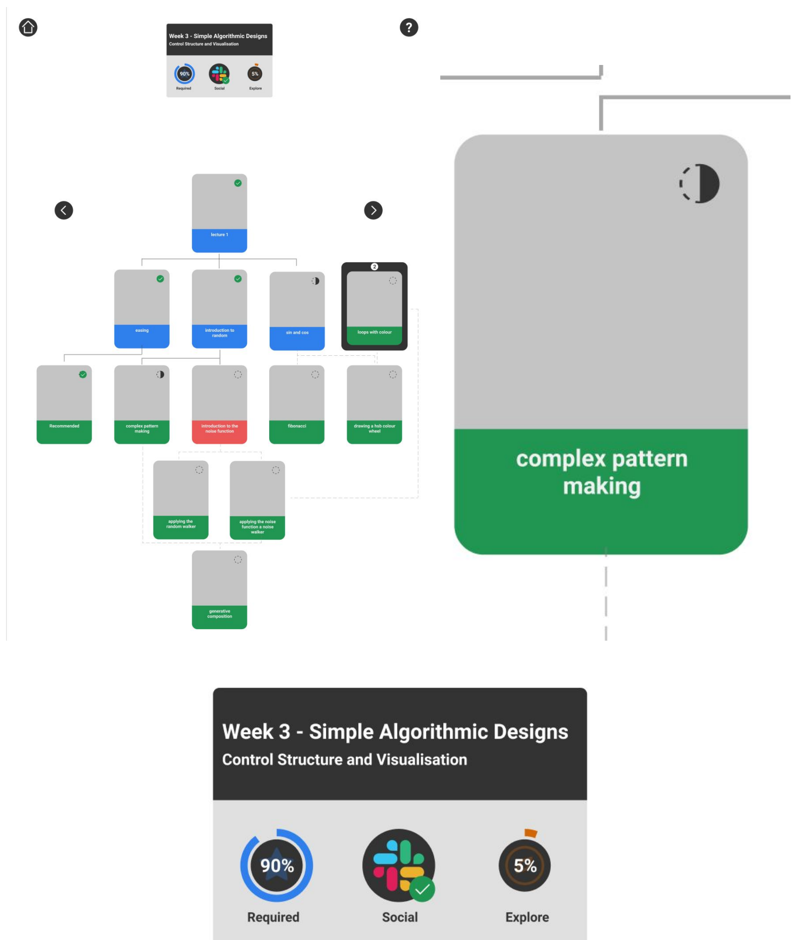

Figure 4.16: A mockup over the overview layout created during the platform design process showing several layouts in the interface: a tree layout, a card layout, and a feedback metric

These mockups were used to guide conversations with developers. They created an explicit understanding of what needed to be done. In some cases, this meant removing aspects that were deemed too difficult within constraints and sacrificing minor aspects of user needs. In others, unique insights from their technical background allowed the team to meet user needs while simplifying design and minimising technical bloat.

4.4.2 Prototype Development

The development team decided on a nuxt.js framework for the application. The predefined file structure of the web-app template meant the team could spend less time on web-app file structure setup and more time on developing the mockups. Because of this slack integration and feedback metrics from the mockups could not be implemented. This was a substantial sacrifice of user needs in order to deliver the prototype on schedule. The implications of this sacrifice are not directly related to the research objective of this research.

Nuances design patterns for labels and social integration were altered to suit the interaction affordances of programming frameworks used. We predicted this would significantly impact satisfaction of user needs, particularly those relating to feedback design. The development team focused on adhering to mockups as much as possible within the given technological constraints.

The overview followed similar structural design patterns to the mockups. Figure 4.17 illustrates this overview with higher fidelity design of the working prototype.

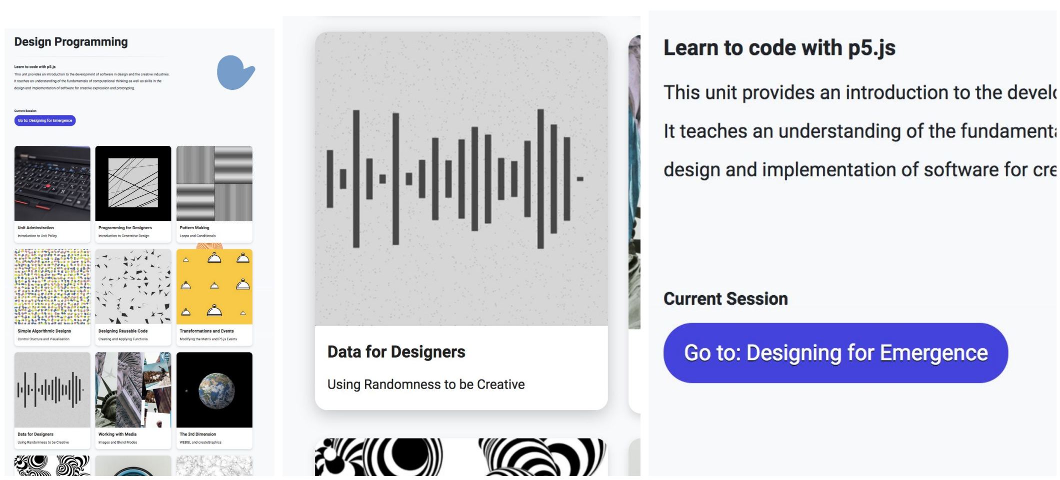

Figure 4.17: Three aspects of the developed prototype: an overview, a card and a call to action button

A notable difference is the replacement of the ‘this week is’ section with a ‘current session’ button. We predicted the replacement of feedback metrics with a button to have a major satisfaction impact. Another difference is the lack of badges on week cards. We predicted this would also affect potential user satisfaction. Implicitly specified in mockups, we included visual aids in the form of card images for the overview. This aimed to encourage student goal orientation through visual aids. These images were taken from a 2018 instance of the platform and reintroduced on the basis of goal orientation.

The week view also followed similar structural design patterns to the mockups. Figure 4.18 below illustrates the week view with higher fidelity design of the working prototype.

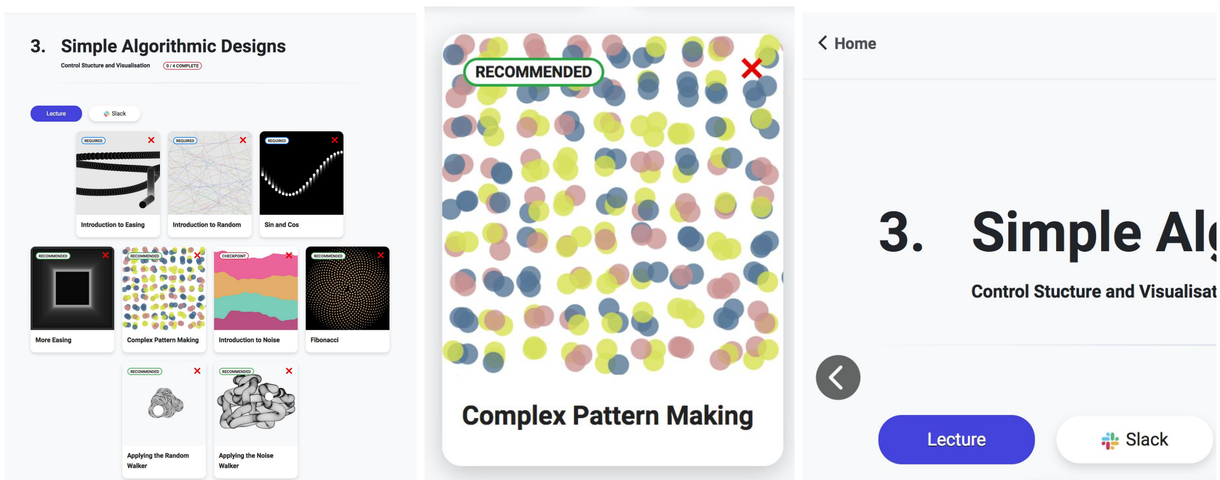

Figure 4.18: Aspects of the interface of the platform week view. a tree layout, a card layout, and a set of navigation buttons

A notable change is the design patterns used to distinguish OLT categories. Labels have been added and coloured title backgrounds removed. This was a collective decision to reduce colour on the page and limit distraction. Having both an image and a colourful card was too distracting and we believed goal orientation and cultivation of motivation to learn would be discouraged as a result. A library of icons was used to replace the designed and agreed upon in the mockups. This impacted design themes but we predicted not a major reduction in user satisfaction. Similar to the overview, a button has replaced the feedback metrics at the top of the view.

4.5 Stage 5: Meta-design Prototype Development

The aim of the meta-design prototype was to communicate instructional strategy through design patterns that our research suggested positively affected the encouragement state. This guide would be used by recent graduates of design programming in the first assessment of the Web Design and Technologies course. The assessment was rebuilt around the guide, with the rubric structured to allocate top marks to exemplary student-made challenges while focusing on the learning outcomes of the course. Exemplary student-made challenges were shortlisted for design review by experts for future curation as part of the eLearning platform in 2021 semester 1 of Design Programming.

We validated this prototype through analysis detailed in the 5th Phase of Research (see Section 3.5). This validation deepened our understanding of research objectives and established potential design criteria for future iterations of this framework and the meta-design of student-made challenges. Due to the specificity of findings and design insights, this stage was conducted a part from the Research Team. Members were consulted as teaching experts as part of validation in this design process. A complete version of this prototype can be found at https://halcha.github.io/challenge-recipe/ or see the appendix to be directed to a local copy.

4.5.1 Instructional Strategy

Instructional strategy was based on the criteria established through conceptual design with the research team (see Section 4.4.3). The steps of creating a challenge were structured in discrete sections. The section structure was an interpretation of the methods used in the challenge creation workshop during the challenge review (see Section 4.2).

To better ground these drafts, we created an example challenge in tandem with the assessment guide. This allowed us to iteratively test the guide as it was written and designed to identify faults in instructional strategy. Based on the need from the design programming course coordinator the example challenge covered the concept of transforming shapes. We followed the guide from insights gained thus far in the Research through Design Process to make a challenge we believed would be associated with a positive encouragement state. This would guide us to create instructional strategy in the assessment guide and that would guide students to do the same with their assessment challenges.

Through feedback based iteration and tandem design of example and guide, we deepened our understanding of the nuances in the instructional strategy and how they are best integrated into design patterns. These concepts were then visualised through mockups.

4.5.2 Mockups

The aim of the design mockups was to communicate instructional strategy using the most suitable design pattern that positively affected the encouragement state. The design would focus on the criteria defined during conceptual design (see Section 4.3.3). We used current online article formats as a precedent. Due to a discovered design need of simplicity (see Section 5.2) we presented design patterns in a minimalist format based on precedents such as Medium (Botticello, 2019). These minimalist principles applied in different ways depending on the components and the design patterns they were based upon. We found large margins, adequate line spacing and text size to represent emphasis, were effective ways to begin this structuring process. In blocks of text this encouraged text ‘milking’: a method of perceiving rhetorical patterns in text quickly (Bell, 2001). In other components such as the code editor, margins were not applied. This allowed a better use of the screen space for <iframe> content. Figure 4.19 below illustrates these patterns below.

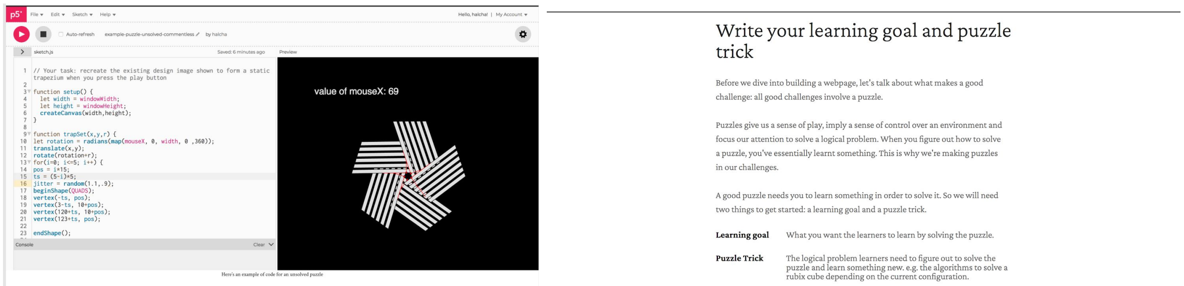

Figure 4.19: Design Patterns of Assessment Guide based on research and precedents

Feedback was provided by the Course Coordinator of Web Design and Technologies and Research Team members. Feedback focused on navigation of the guide and copy involved in instructional strategy. This informal feedback given on the user interface from these expert stakeholders was unanimously positive. We believed this demonstrated implicit expert support that both the assessment guide and example effectively used the design patterns that positively affect the encouragement state. We found supporting findings of this idea during analysis of Phase 3 Evaluation Data (see Section 5.3). Figure 4.20 below demonstrates this similarity of before and after feedback design patterns.

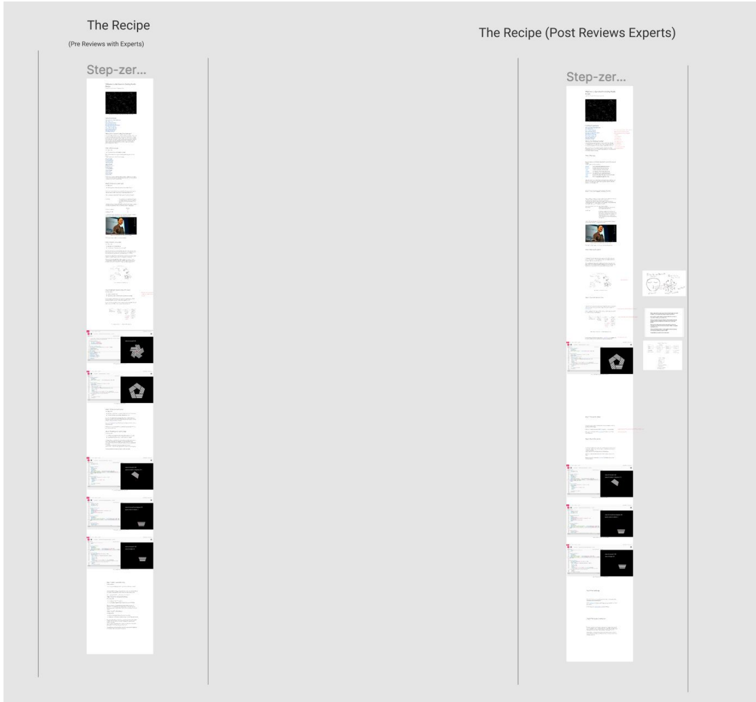

Figure 4.20: Design Patterns remain relatively unchanged after feedback

We also collaborated with the Course Coordinator of Web Design and Technologies to create an Assessment Description and Criteria that would incentivise the creation of exemplary student-made challenges using design patterns that positively affect the encouragement state. Figure 4.21 below details this rubric.

2: Creative Coding Challenge (20%)

In this assessment, you will create a web-based tutorial to help students of Design Programming become better coders. Your "creative coding challenge" should be a short, interactive tutorial on a P5.js topics chosen from the list below. Choose a topic that you feel would have been helpful to learn when you studied Design Programming.

Provided Topics:

- **Random** understanding and using random floating-points
- **Sin and Cos** mapping values to the sine and cos waves
- **Easing** smoothing transitions between two values
- **Functions** creating sets of statements to perform a task or series of steps
- **Transformation** manipulating the canvas origin and orientation
- **Arrays** creating list-like objects that code can traverse and mutate
- **Images** representing .png, .gif, and .jpg files in the canvas

A challenge recipe and example challenge will be provided to aid your design. You will use these along with the provided component library and boilerplate template to develop your challenge.

Submission: This assessment will be submitted on Canvas by providing a repl.it link attached to a Github code repository.

Assessment Criteria

High Distinction	Distinction	Credit	Pass	F
Application of Information Architecture				
Content is extremely well organised, with excellent application of information architecture to provide a clear and enjoyable educational experience.	Content is neatly organised, with good application of information architecture to provide a clear educational experience.	Content is presented with appropriate application of information architecture.	Content is presented, with some application of information architecture.	Content is illegible, or unrelated. No application of information architecture is evident.
Quality of Implemented Code				
Implemented code shows a complete understanding of semantic HTML elements.	Implemented code shows a clear understanding of most semantic HTML elements.	Implemented code shows understanding of some semantic HTML elements.	Implemented code shows understanding of the basic HTML elements.	Implemented code shows no understanding of HTML elements.

Figure 4.21: The Web Design and Technologies Assessment Description and Criteria.

After establishing the design patterns to communicate the instructional strategy through mockups as well as the Assessment Description and Criteria, we transitioned to the design of a functional prototype.

4.5.3 Prototype Development

The aim of the Design Prototype was to translate the design patterns and instructional strategy written and visualised in the mockups onto a Website. We developed the Assessment Guide in HTML CSS and JavaScript. It was then hosted through Github Pages to begin functional testing with expert stakeholders. The focus of this feedback remained on navigation and instructional strategy with the emphasis on minor nuances a working prototype can communicate that is not as visible in the mockup stage. One such instance was the use of the "_blank" value for the "target" attribute within the anchor element tag linking to other webpages in the HTML of the prototype. Through this configuration, the assessment guide would remain consistently available as a tab on student browsers and establish the assessment guide as the main document.

A major iteration from expert feedback was the modularisation of the web page through CSS. From experience of teaching online content, experts experienced a lack of interest from students who are greeted with too much content at once. This aligned with our results from Phase 2 of the research (see Section 5.2). Experts believed by modularising our content from the long scroll format into sections students would be oriented to their main task and visually understand when subtasks were complete. Figure 4.22 below demonstrates the difference in visual output between these two styles for the Assessment Guide.

Figure 4.22: The comparison between an infinite scroll style and modular style guide

A major assessment requirement was the need to provide students with a forkable repository which they could use as a template for their assessment submission. Figure 4.23 below illustrates the repository provided to students using the *repl.it* platform to facilitate asynchronous code collaboration between students and tutors.

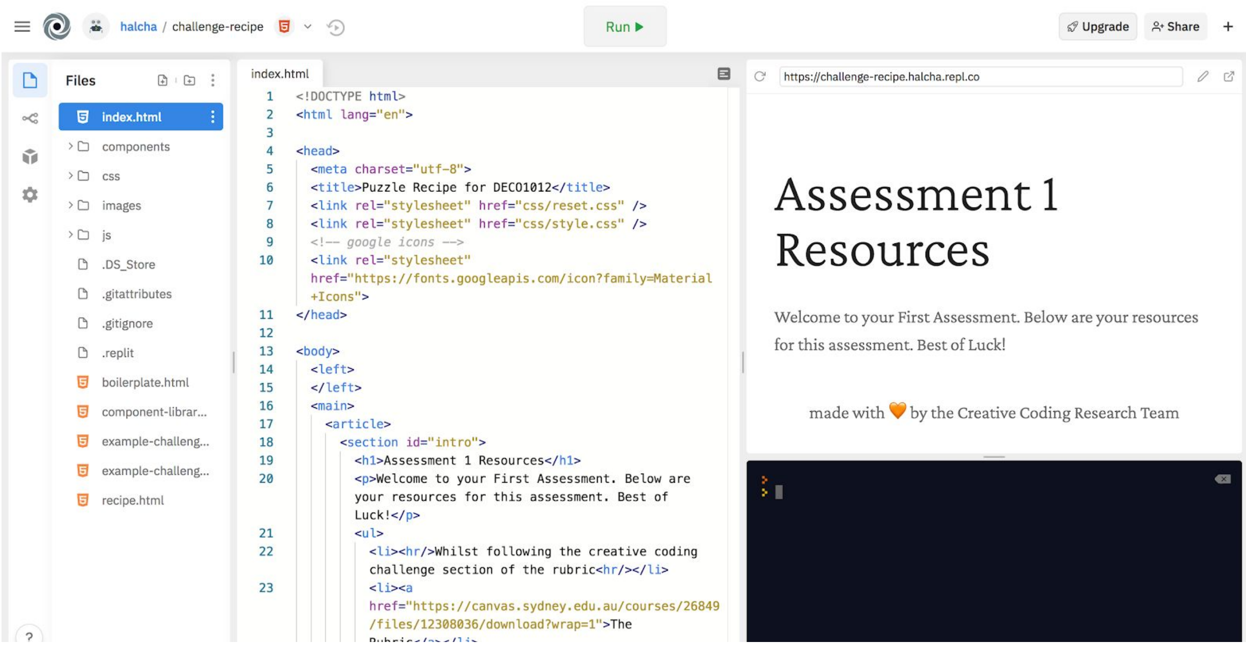

Figure 4.23: The Creative Coding Challenge Assessment on the repl.it platform.

Validation of this prototype was conducted during Phase 3 of Research (see Section 3.3). Because the assessment was released when this Phase was conducted, only minor feedback that did not impact the instructional strategy could be used to iterate the prototype. One example of this is the addition of an index page to list all the available resources as part of the guide when students loaded the repl project. Figure 4.24 below illustrates this index page.

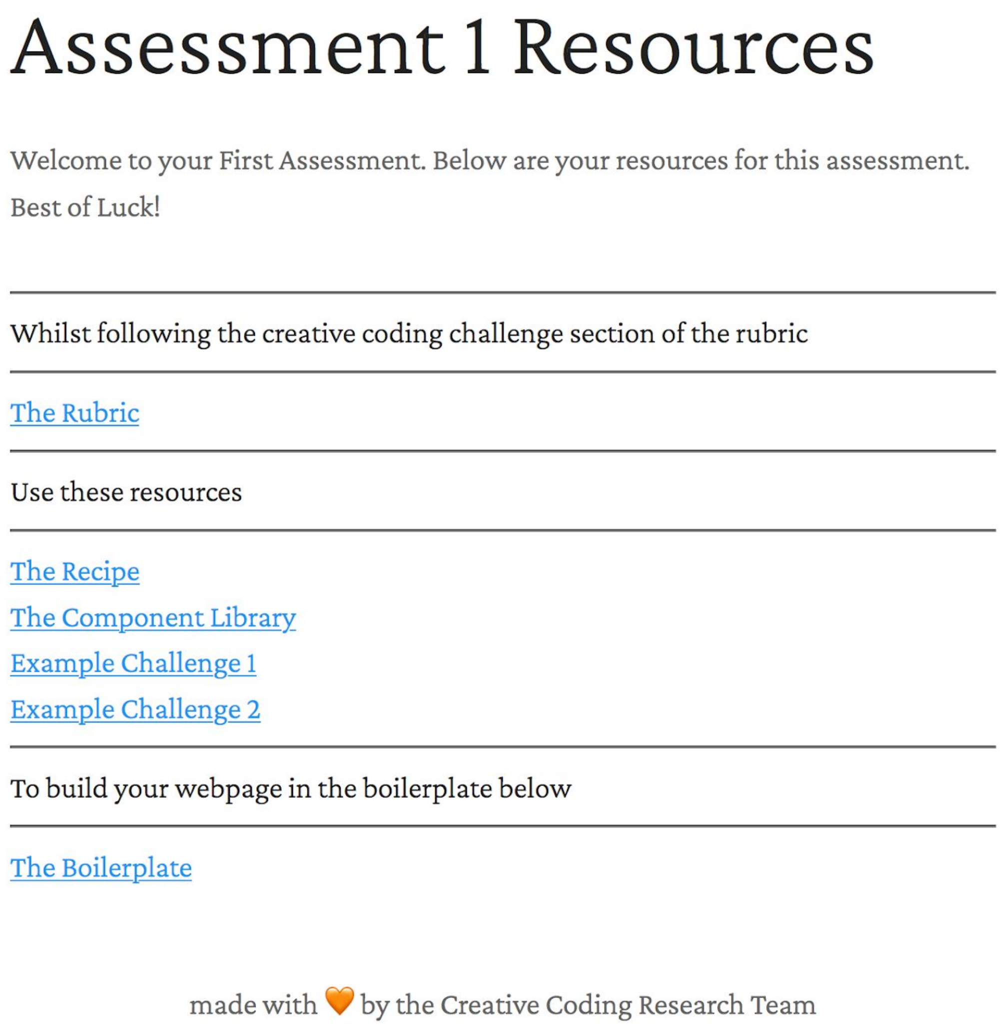

Figure 4.24: The index page added based on feedback during Phase 3 of research.

The delineation of stages throughout this meta-design prototype process demonstrated its value during functional testing. By defining the relationship between instructional strategy and design patterns in the mockup phase, we could quickly iterate to reach design goals as validated by expert feedback. This allowed us to focus on functional issues during prototype development and prioritise user experience of functionality which has been demonstrated in Phase 2 of our research to inhibit a students experience with an online learning platform regardless of design pattern (see Section 5.2).

Chapter 5
Results

5.1 Results of Phase 1

Phase 1 was an exploratory analysis of challenge feedback data provided by students during Semester 1 of 2020. This feedback was parsed from a JSON file to a csv where the Likert Score could be analysed to reveal the association of a challenge with the encouragement state: a broad term for experiences that encourage or discourage an individual to cultivate motivation to learn. Archetypal challenges were then chosen and compared the reveal results.

The results of Phase 1 are in three parts. The first was a collective perception of encouragement according to Likert scales of Understanding, Enjoyment, Ease and Learning. The second was a classification of challenges by prevalence of design patterns. The third was challenge submission rate over Semester One of 2020. By combining these results, we revealed what design patterns were prevalent during the collective encouragement states of students engaging with challenges and this shift over time during Semester One of 2020. To conceptualise results from this spreadsheet, we've included a set of figures and tables. Also included is a brief description of our result interpretation and dataset exploration to acquire subsequent results in Phase 1. This is expanded upon in the discussion (see Section 6.1). Our deepened understanding of the effects of design patterns on the encouragement state of students engaging in challenges is based, in part, on these results.

Figures 5.1 and 5.2 illustrate the first part of Phase 1 Results. These are the average scores of challenges in the four Likert Scales of Understanding, Enjoyment, Ease and Learning across the student cohort of semester one 2020.

Figure 5.1: Average Understanding and Learning Likert Scores for Challenges.

Figure 5.2: Average Enjoyment and Ease Likert Scores for Challenges.

We began the second part, a classification of challenges by prevalence of design patterns, with a consideration. Behrens suggests effective EDA involves hypotheses about the causes of observed phenomena (1997). To better understand what design patterns were prevalent in different states of motivation, we considered observable trends from Likert results illustrated above. From this consideration, we hypothesised the following:

"Design patterns of a challenge will differ when a student is encouraged or discouraged to cultivate motivation to learn."

To test this hypothesis, we categorised challenges by prevalence of design patterns. The categorised challenges were then divided into a binary relationship to interpret simplicity from complexity of categorisations (Simon, 1996). This division was based on encouragement state as represented by Challenge Likert scores.

We followed two routes of division. The first was combining Likert scores to create a combined score which loosely defined encouragement state for a challenge in one value. The highest and lowest four challenges then became archetypes for classification. The second was keeping Likert scores separate and selecting the highest and lowest ranked challenges from each of the four Likert Scales as archetypes for classification. In both routes, the line of regression was calculated challenge with values above this line were considered as an encouraged state. Challenges with values below this line were considered a discouraged state. We analysed data through both routes and compared the results. Tables 5.1 and 5.2 represent these results below.

OLT	Aggregate Likert Score	Encouragement State
Basics of Drawing to Canvas	3.92	Encouraged
Using the Draw Loop	3.82	Encouraged
My First Sketch	3.64	Encouraged
Patterns Using Loops	3.59	Encouraged
Custom Behaviours	2.73	Discouraged
Applying GUI	2.70	Discouraged
Recreating Existing Design Part Two	2.09	Discouraged

Forms and Behaviours	1.67	Discouraged

Table 5.1: Archetypal challenges chosen through combined a Likert Score

OLT	Likert Score	Encouragement State	Scale
Basics of Drawing to Canvas	4.25	Encouraged	Understanding
Using the Draw Loop	4.09	Encouraged	Enjoyment
Patterns Using Loops	3.32	Encouraged	Ease
My First Sketch	3.28	Encouraged	Learning
Forms and Behaviours	1.67	Discouraged	Understanding
Recreating Existing Design Part Two	2.77	Discouraged	Enjoyment
More Fun with Sin and Cos	2.29	Discouraged	Ease
Applying GUI	2.42	Discouraged	Learning

Table 5.2: Archetypal challenges chosen through separate Likert Scores

In following the method of challenge choice illustrated in table 5.2, we did not include duplicates i.e. one challenge had the highest understanding and enjoyment score. This was to maintain 8 separate challenges from which we could classify design patterns. Because of this variance, gained a more holistics representation of what patterns positively and negatively affect the encouragement state.

It was observed 6 out of 8 challenges were the same between Tables 5.1 and 5.2. If the two routes of division yield such similar results, this indicates a high correlation between the four Likert scales. This prompted us to explore bivariate correlation using the Pearson coefficient.

The Pearson Coefficient is a measurement of linear correlation between two variables (Pearson, 1895). A value of 1 is total positive linear correlation, 0 is no linear correlation, and −1 is total negative linear correlation. To explore this coefficient further, we considered in tandem Figures 5.3 and 5.4 below. An example of positive linear correlation is if all students gave all challenges a score of 3 for enjoyment and 3 for learning, the column graph in Figure 5.4 would give the 'Enjoyment x Learning' column a value of 1. Any differences between aggregate Likert Scores would deviate from the absolute value of 1; either positive or negative. Figure 5.3 visualises potential data relationships on a scatterplot graph and Figure 5.4 visualises the Correlation of Average Likert Score across all challenges.

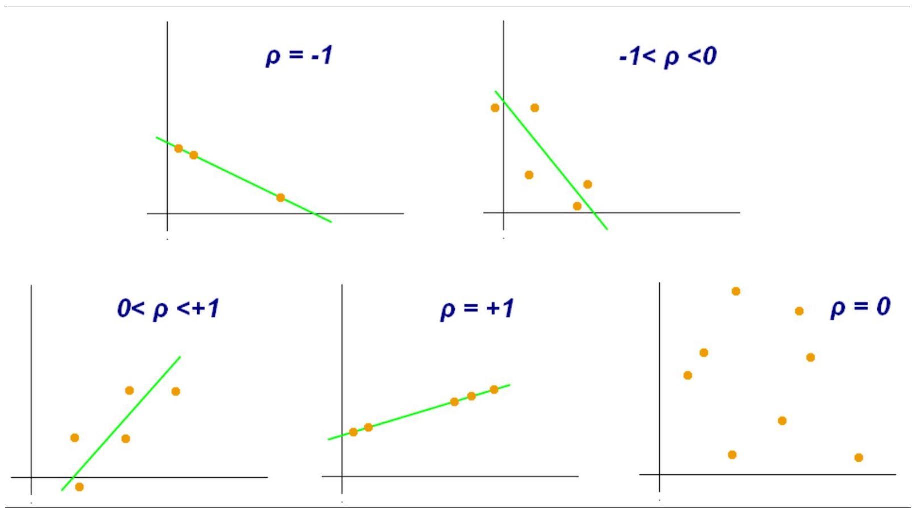

Figure 5.3: A visualisation that maps Pearson Coefficient *to linear correlation between two values (Kiatdd, 2012).*

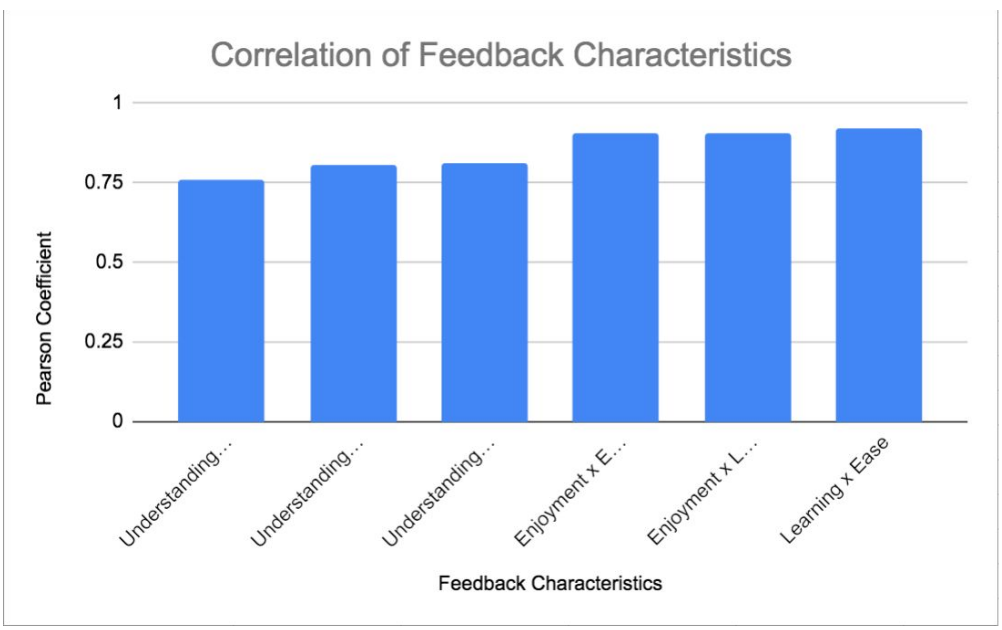

Figure 5.4: Pearson Coefficient for Correlation of Average Challenge Scores.Typically, anything over 0.5 is considered a strong correlation and anything over 0.9 is considered a measurement of the same characteristic

In considering these results, we discovered that all the Likert scales had a Pearson Coefficient greater than 0.76 and Learning and Ease had the highest correlation of 0.92 to two decimal places. These results supported our generalisation of sentiment towards challenge being related to the encouragement state. This was another perspective that clarified the routes of division to choose challenge archetypes were equal in their indication of encouragement state.

The archetypes presented in tables 5.2 above were classified through the prevalence of design pattern classifications established in the analysis of Phase 1 (see Section 3.1.2). Table 5.3 below represents these 9 classifications.

Classification Code	Classification Name
1	Navigation Components
2	Community Support Component
3	Links to Additional Content
4	Text-Driven Component
5	Visually-Driven Component
6	Goal Orientation Component
7	Task-Based Structure
8	Code-Driven Component
9	Code Editing Component

Table 5.3: Design Pattern Classifications.

Figure 5.4 below shows the results of this classification.

	Challenge Nam	Basics of Drawir	Using the Draw I	Patterns Using L	My First Sketch	Forms and Beha	Recreating Exist	More Fun with S	Applying GUI
Classification Name	**Code**	a	b	c	d	e	f	g	h
Navigation Components	1	0	0	0	0	0	0	0	0
Community Support Component	2	0	0	0	0	0	0	0	0
Links to Additional Content	3	0	0	3	0	1	0	6	1
Text-Driven Component	4	6	8	5	9	22	11	6	8
Visually-Driven Component	5	3	1	2	2	2	5	2	2
Goal Orientation Component	6	2	2	2	3	3	2	3	2
Task-Based Structure	7	2	3	3	2	8	7	3	3
Code-Driven Component	8	1	0	2	1	1	0	0	2
Code Editing Component	9	2	4	2	2	8	4	2	1
Total		16	18	19	19	45	29	22	19

Figure 5.4: Results from Classification of Challenges by Design Pattern Prevalence.

Figure 5.5 below shows a visualisation of these results. Encouraging and discouraging challenges are delineated through the column colours of green and red respectfully.

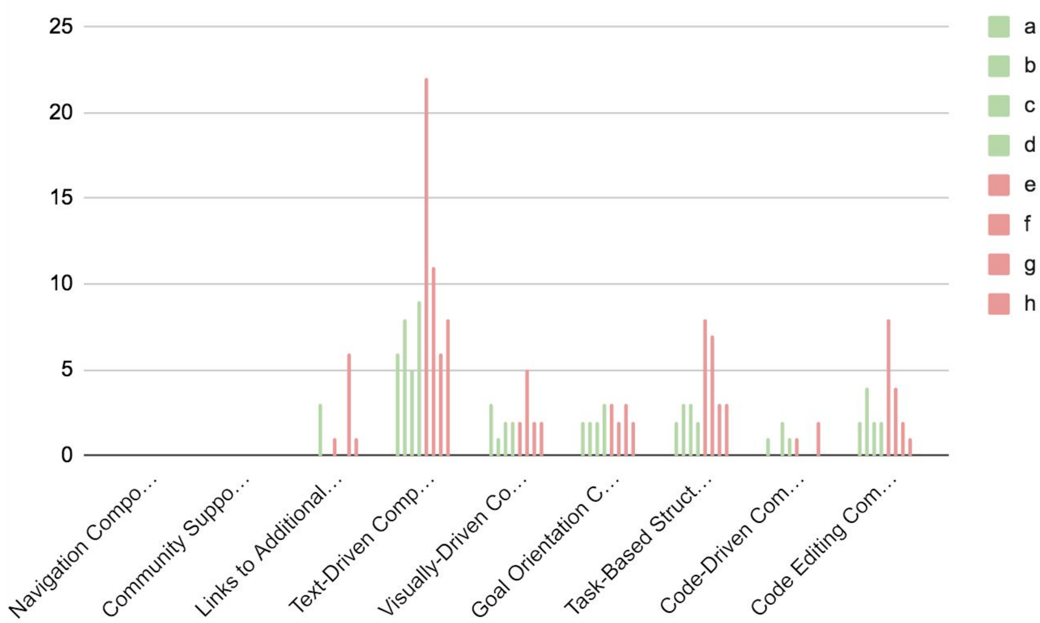

Figure 5.5: Results from Figure 5.6 visualised as a bar graph.

Along with prevalence, these results reveal type and grouping of design patterns in challenge archetypes. These results are discussed further in Section 6.1.1. There, they are compared to other factors involved in the encouragement state discovered through the other phases of research.

The third part of Phase 1 results began with observation of the challenge submission rate over semester one of 2020.

Figure 5.6 below illustrates this observation. The x-axis details the series of challenges ordered by average submission time as recorded as a UNIX timecode to the millisecond: just to be safe. The y-axis details the number of participants who completed a successful submission of a particular challenge.

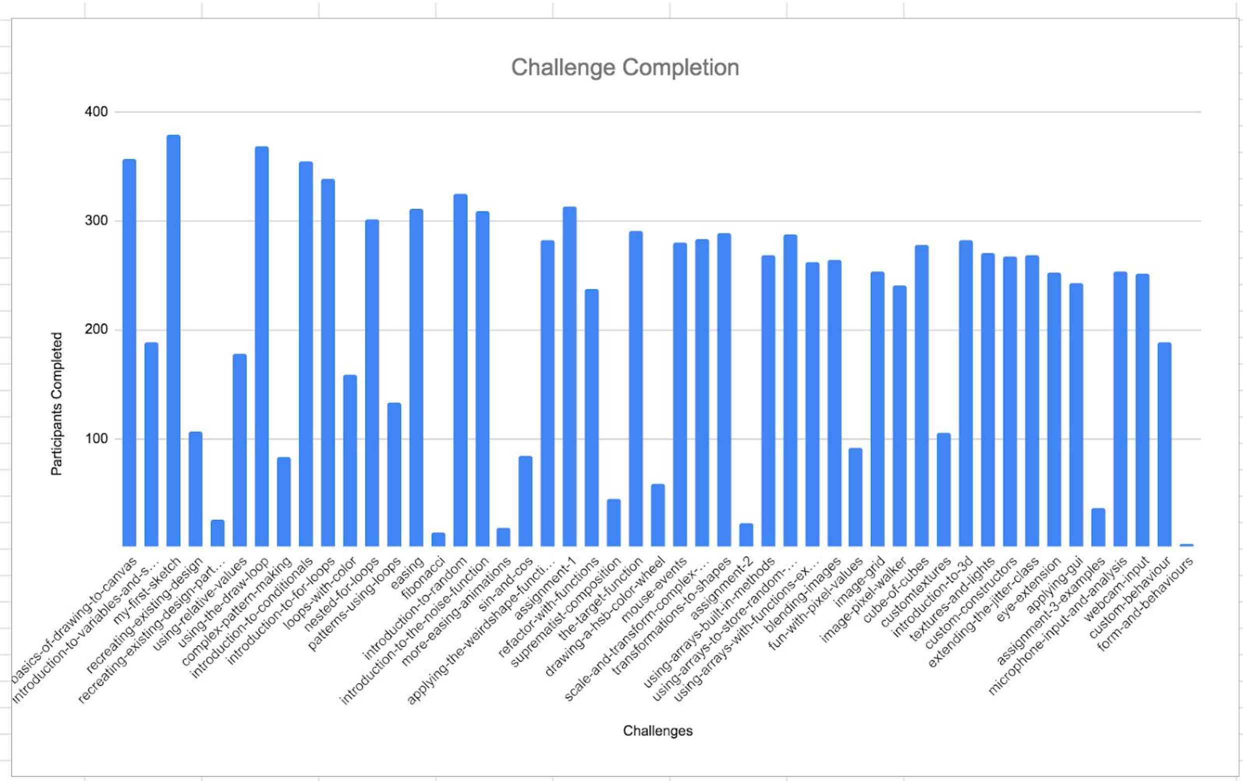

Figure 5.6: Challenge Submission rate for Semester 1 2020, showing the gradual falloff in online learning platform participation over the semester.

In comparing the three sections of results in Phase 1, another hypothesis was formed:

"Submission rate is correlated with the encouragement state."

As time progressed, we observed a general decrease in the challenges completed. Based on our formed hypothesis, we believed something about the learning experience of later weeks was discouraging students from completing challenges. However, when considered against the archetypes of Likert scales, it was suggested that time alone was not the solely responsible for this drop in encouragement. Figure 5.7 offers an alternative perspective supporting this idea.

The series on the x-axis represent challenge archetypes of encouraged or discouraged states in green or red. This series is measured on the y-axis but average week submitted. As Figure 5.6 below illustrates, encouragement may favour earlier weeks but it is not without discouraging states. These drops in encouragement can also be seen as a reflection of submissions in Figure 5.6 above as part of the larger dataset.

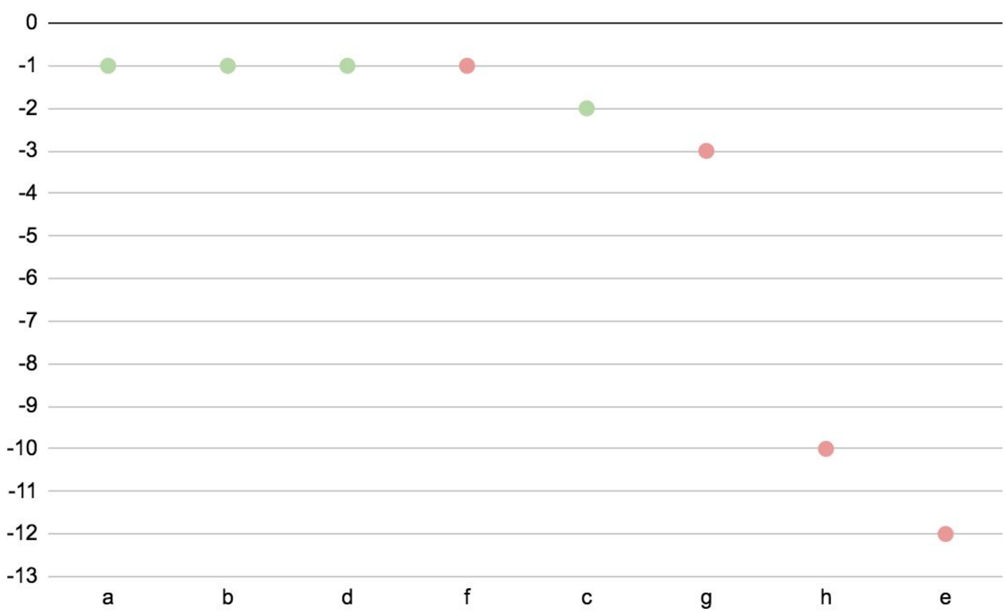

Figure 5.7: Challenge archetypes favour an encouraged state in earlier weeks and a discouraged state in later weeks.

Further discussion on Phase 1 of Research can be found in Section 6.1.1.

5.2 Results of Phases 2 and 4

The results of Phase 1 dynamically deepened our understanding of research objectives over the course of Semester One. For instances where the quantitative data left questions unanswered, The results of Phases 2 and 4 provided insights. Specifically, the relationship between design patterns in challenges and the encouragement state. Qualitative data in the form of transcripts were recorded from 34 separate interviews. These were fractured into 832 quotes and coded with 46 unique codes to provide themes. These themes emerged spontaneously during the coding process to “make sense of collective or shared meaning and experiences.” (Braun & Clarke, 2012). Of these 46 unique codes, there were 1,462 instances of their use. This is because 56% of quotes recorded contained two codes. We believe this majority of double coding stems from an interdependent co-arising of user needs: a presence of not only direct needs but tacit needs identifiable in single quotes.

Due to the complexity of student needs in our research context, we could expect to see changes across connected themes through the effects of design prototypes and their subsequent validation in interview rounds Phases 2 and 4 across Semesters 1 and 2 of 2020. The figures below represent the visualisations used to better understand results of thematic analysis. These allowed us to draw insights and iterate conceptual design through the RtD process. In consideration of Strauss & Corbin’s belief (1998) that “the context in which the concept is used should indicate meaning”, insights are discussed across Chapter 6 to better explore the context of insights from Phases 2 and 4.

Figure 5.8 below visualises the structure of the coding process our interpretation of “The analytic processes through which data are fractured, conceptualized, and integrated to form theory” (Strauss & Corbin, 1998)

	A	B	C	D
1		ID All	Theme Tag All	Theme 2 Tag
2				
3	**ID**	**Quote**	**Theme Tag**	**Theme 2 Tag**
19	P1	[creative coding platform] In introductory part and the exploratory part and the advanced part. Yeah. Something that I think is very great.	Challenge Categories	
20	P1	[introductory, exploratory, advanced, creative titles] I think it's a great way to strategise, to make a kind of, uh, this small titles and because it's very clear to see... what I'm doing now, um, because when I doing some... basic challenge, maybe I will feel more comfortable to do that.	Purpose Understanding	Challenge Categories
21	P1	[process of completing challenge] so first he shows the, uh, example about this one.	Clarification	
22	P1	[process of completing challenge] So first I would like to read the introduction of this kind of discrimination of this challenge first.	Student Workflows	Challenge Categories
23	P1	[process of completing challenge] before I start, uh, doing this code, I'd like to think first how do you draw these kind of things.	Student Workflows	Concept Understanding
24	P1	[process of completing challenge] I like to use the, um, p5.js reference	Student Workflows	External Resources
25	P1	[process of completing challenge] normally I like to draw, uh, draw my coding and I show something like this in a few first because auto refresh, it's very convenient.	Student Workflows	Learning Boost
26	P1	[process of completing challenge] So after I finish my brainstorming or something like that, I actually just copied our code from here and then turn back to this side.	Student Workflows	External Resources
27	P1	I think the way to do the Python and Java script, they have some similarities	Experience with Code	
28	P1	More the interactive tutorial. Uh, instead of just, um, read through the slides.	Class Engagement	Learning Structure
29	P1	when I, uh, look up the slides online I can understand the content first.	Student Workflows	
30	P1	[when] I really do the challenge myself will be confusing for me too and you know, how do you use the knowledge practically.	More Explanation	Purpose Understanding
31	P1	[when stuck on challenge] Yeah, I need some help from others	Social Guidance	

Figure 5.8: Interview transcripts fractured into quotes and thematically coded.

Figure 5.9 below illustrates the number of unique quotes per participant. With the aim of "working out how the things that people do make sense from their perspective" (Ezzy, 2013), This was useful in considering the importance of a theme to a participant by observing its prevalence within a transcript.

ID	Unique Quotes	Unique Tags
P12	5	5
P13	7	9
P10	9	12
P17	9	12
P18	11	8
P11	12	11
P14	12	17
P19	12	13
P23	12	13
P15	13	14
P8	13	13
P21	14	14
P16	15	15
P22	15	13
P31	15	9
P32	18	12
P33	18	11
P9	20	18
P20	21	15
P24	21	18
P4	24	23
P7	25	17
P34	26	14
P5	29	14
P2	33	20
P3	33	24
P27	35	21
P30	35	18
P1	36	20
P29	38	20
P28	50	23
P6	55	26
P25	65	28
P26	76	27
Grand Total	**832**	**43**

Figure 5.9: Challenge archetypes favour an encouraged state in earlier weeks and a discouraged state in later weeks.

Figure 5.10 illustrates a pivot table of participants and prevalence of themes. This a more detailed expansion of Figure 5.9. In both figures, using a heat map allowed us to quickly identify prevalent themes in various contexts when considering research insights and design needs through an RtD Process.

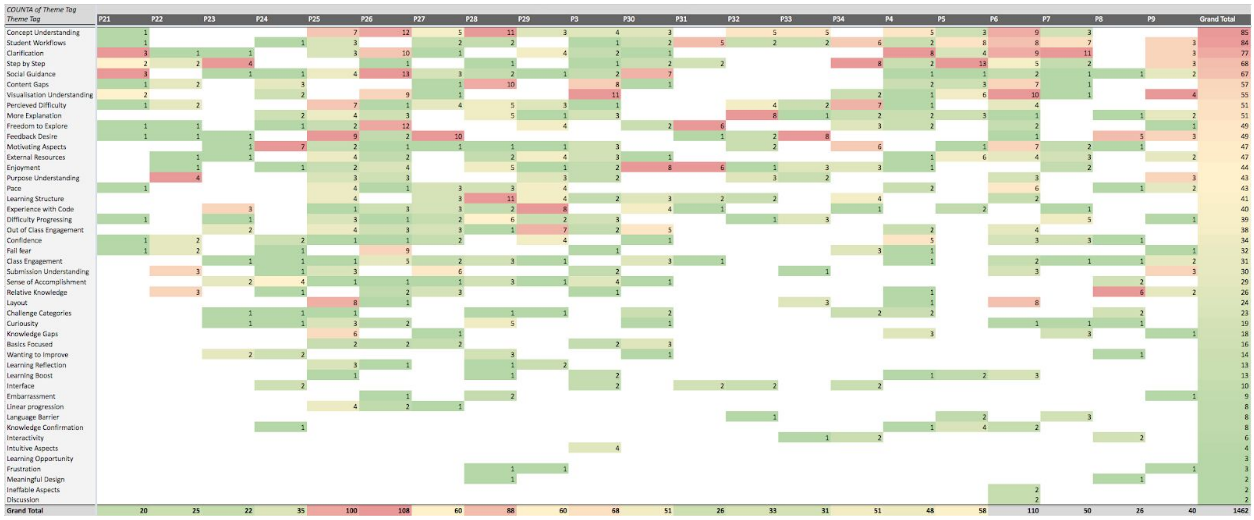

Figure 5.10: Challenge archetypes favour an encouraged state in earlier weeks and a discouraged state in later weeks.

Table 5.4 below details the coded themes from Phases 2 and 4 which are implicitly considered in relation to design guidelines in Chapter 6.

Thematic Code	Prevalence in Conversation
Concept Understanding	85
Student Workflows	84
Clarification	77
Step by Step	68
Social Guidance	67
Content Gaps	57
Visualisation Understanding	55
Perceived Difficulty	51
More Explanation	51
Freedom to Explore	49
Feedback Desire	49
Motivating Aspects	47
External Resources	47
Enjoyment	44

Purpose Understanding	43
Pace	43
Learning Structure	41
Experience with Code	40
Difficulty Progressing	39
Out of Class Engagement	38
Confidence	34
Fail fear	32
Class Engagement	31
Submission Understanding	30
Sense of Accomplishment	29
Relative Knowledge	26
Layout	24
Challenge Categories	23
Curiosity	19
Knowledge Gaps	18
Basics Focused	16
Wanting to Improve	14
Learning Reflection	13
Learning Boost	13
Interface	10
Embarrassment	9
Linear progression	8
Language Barrier	8
Knowledge Confirmation	8
Interactivity	6
Intuitive Aspects	4
Learning Opportunity	3

Frustration	3
Meaningful Design	2
Ineffable Aspects	2
Discussion	2

Table 5.3: Archetypal challenges chosen through separate Likert Scores

Table 5.4 below outlines the notions reveals collation of these themes

Notion	Description
Complex content	In reading content, students expressed observation of dissonance between their perception of instructional strategy and how that applies to the task the strategy aim to guide student to effectively complete
Text walls	The initial response to large amounts of text in a challenge as part of this eLearning platform leads to the discouragement state.
Learning by teaching	students support the process of teaching others that in explaining programming concepts they must create effective Syllogisms i.e. logical arguments in their own mind for how certain mechanics function before they can teach effectively. they believe that through teaching, they can personally arrive at an effective understanding of a programming concept which increases their efficacy in its use.
Unguided metaphors	you need an interpreter to explain complex metaphors that explains what the metaphor means, otherwise keep content simple
Navigational stress	The experience of seeing all the challenges often represented for students all the things they didn't understand which was a discouraging experience for most except a the high achiever who considered this a challenge to overcome in itself.

Content balance	students felt challenges that use a variety of design patterns well balanced to form a holistic perspective of a concept were more encouraging than challenges that were polluted with a certain design pattern
Integrate solutions	including solutions as part of challenges was universally supported and mentioned independent of prompting questions. Some reasons given included the ability for advanced students to optimise their solution with the best solutions, helping people who missed a step catch and and the feeling of support knowing that the solution is there provided. it was also seen to shift the competition from being the first to submit a solution to being the first to understanding the code.
Code editors	conversation included how to use code editors, what's the best way to put comments in code editors, and when makers but themselves in the position of learning, general student encouragement from using code editors in challenges
Visuals as guides	students are encouraged by visuals they can aspire to recreate or use as conceptual guides. This was found from feedback on the code process flow and puzzle sketch.
Process diagrams	diagrams that chunk a concept for a task into steps encourages students by helping them feel the task is manageable when chunked into steps.
External resources	external resources interesting for students who are curious about the connection between challenges and its relationship to the p5.js library
Step by step	content is chunked to provide smaller wins, simple goals and easier cognitive load for students. students in focus groups predominantly considered this to be the way in which they conceptualised their own learning process and felt encouraged to see that manifested in a challenge structure

Support	Through experiences of tutors walking students through content, friends collaborating to complete code, seeing slack threads previously made to answer their question, student feel supported, more confident and free from anxiety that impedes performance while maintaining the encouragement for motivation to learn. they feel it's exciting, interesting, unique and provides a safety net. students mentioned if they were provided with the student made challenges, they would feel supported in the knowledge that these were made by people only a semester ahead of them which gave them a concrete goal of understanding the content in a certain amount of time.
UI discouragement	UI issues even minor discourage students when it works, it's invisible and not mentioned in terms of good ui but in terms of other positive aspects like step by step, visual emphasis etc.
Guided metaphor	in cases where metaphors were understood they were extremely useful at improving understanding which brought about a self cultivation of motivation to learn
Team understanding	students answered each other's questions, pointed out flaws and learnt from each during the focus groups. the collective became more engaged as the session continued. we believe this is due to an adoption of self assurance that it was okay for them to lead the conversation
Advice on code	conversation surrounded debugging, understanding code snippets and fluidly moved from conceptual design aspects to practical aspects. this demonstrated the need for social facilitation to alleviate misunderstanding of content that manifested through a spontaneous question
Video content	Video content was seen to be engaging, useful for ESL students, helpful when understanding the syllogism: a logical structure of code and learning from good coding techniques and

	providing a solution at the end of an activity for students to check their work.

Table 5.4: Description of Notions for Focus Groups on meta-design framework

5.3 Results of Phase 3

The results of Phase 3 explore the following reflection of Phase 1 and Phase 2 results as a hypothesis:

The integration of a meta-design framework that cultivates student self assessment and social dynamics in a learning experience will yield a positive increase in motivation and perceived efficacy.

We considered high level notions through thematic analysis in Phase 3 with an emphasis on key aspects of the Assessment Guide students felt positively and negatively affected encouragement state and programming efficacy. As with previous thematic analysis in this research, results questioned, informed and supported concepts established in other phases of research: providing context to data and data to context to reveal meaning.

Figure 5.11 below demonstrates these notions which form a basis of Phase 3 discussion in Chapter 6. These notions were based off existing themes from Phases 2 and 4 and have been observed by prevalence from the focus groups. Where experiences novel to meta-design of challenges emerges, new notions were added or removed. These focus groups were named according to the slack emoji designated to the sessions on the Web Design and Technologies Workspace.

A	B	C	D	E	F	G	H	I
Themes	Encouragement State	Total	Theme Description	Group 1 soccer	Group 2 cricket	Group 3 eightball	Group 4 volleyball	Group 5 golf
complex content	Discouraged	3	In reading content, stu	☐	☐	☑	☑	☑
text walls	Discouraged	2	The initial response to	☑	☐	☐	☑	☐
motivated by rubric	Encouraged	5	the assessment has a	☑	☑	☑	☑	☑
teach or challenge	Both	2	students are unclear w	☑	☑	☐	☐	☐
learning by teaching	Encouraged	3	students support the p	☑	☑	☐	☐	☑
review before teach	Discouraged	2	as a reflection of the th	☑	☐	☐	☐	☑
unguided metaphors	Discouraged	2	you need an interpreto	☐	☐	☑	☑	☐
content balance	Both	2	students felt challenge	☑	☐	☐	☑	☐
integrate solutions	Encouraged	3	including solutions as	☑	☑	☐	☐	☑
code editors	Both	4	conversation included	☑	☐	☑	☑	☑
visuals as guides	Encouraged	3	makers are encourage	☑	☐	☑	☐	☑
process diagrams	Encouraged	3	diagrams that chunk a	☑	☐	☑	☐	☑
code first	Discouraged	4	Student identified a ne	☑	☑	☐	☑	☑
external resources	Encouraged	1	external resources inte	☐	☐	☐	☐	☑
step by step	Encouraged	5	content is chunked to	☑	☑	☑	☑	☑
support	Encouraged	3	the presence of the as	☐	☑	☑	☐	☑
UI discouragement	Discouraged	4	UI issues even minor c	☑	☐	☑	☑	☑
assessment guide unn	Encouraged	1	for students who unde	☐	☐	☑	☐	☐
guided metaphor	Encouraged	2	in cases where metapl	☐	☑	☑	☐	☐
team understanding	Encouraged	4	students answered ea	☑	☑	☑	☑	☐
advice on code	Encouraged	1	conversation surround	☐	☑	☐	☐	☐

Figure 5.11: Thematic Notions discussed during focus groups of Phase 3 research.

Because the notions observed share many similarities with the notions from Phases 2 and 4, we've detailed them in the appendix in Table 5.4 and can be found in the appendix under phase 3 materials.

5.4 Results of Phase 5

As tasking experts with hundreds of unpaid evaluations would be impractical and a clear violation of ethics via cruelty, this was complemented with quantitative analysis. A comparison of marks across 2019 and 2020 was conducted. We observed the changes in marks between the two cohorts. One with access to our design prototype and workshops to discuss its use. The other without this access from previous years of study. Figure 5.12 below illustrates the first iteration of this comparison.

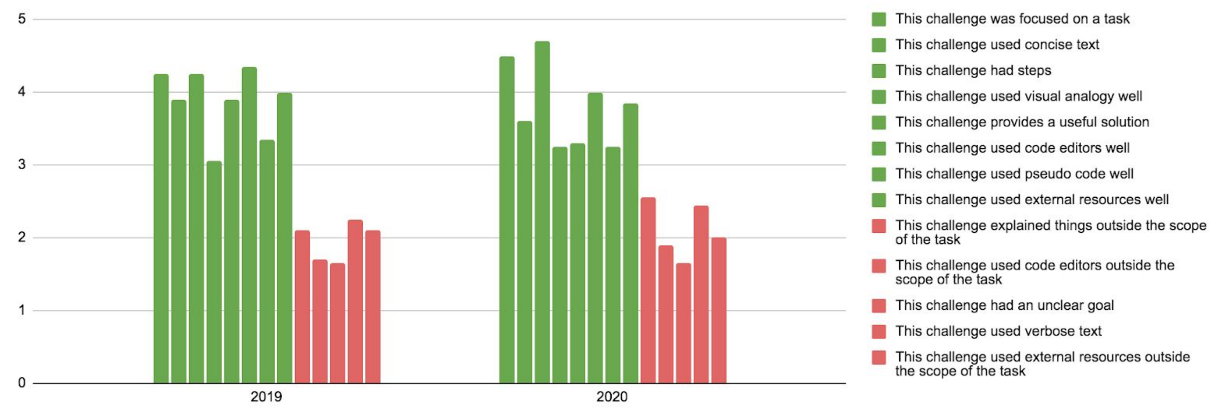

Figure 5.12: High Performer Challenge comparison by Aggregate Question.

Figure 5.13 below clarifies the complexity of findings in 5.12 by combining encouraging and discouraging heuristics to illustrate an average of evaluation heuristics.

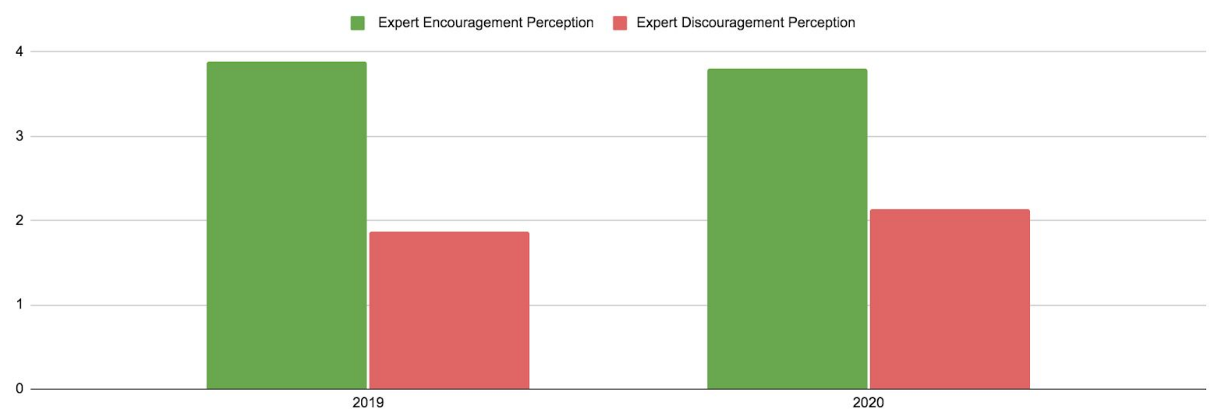

Figure 5.13: High Performer Challenge comparison by perceived encouragement state. Despite the improved student perception of the meta-design prototype, expert ratings of the best challenges remained comparable.

This demonstrates that according to experts surveyed, there is negligible effect of a meta-design framework for High Performers. However, all challenges reviewed exceed the average Likert responses for challenges in the platform. To observe the effect of meta-design for the remaining cohort, we compared assessment marks of the cohort. This avoided cruelty involved in tasking the programming tutors with hundreds of unpaid evaluations. Figure 5.14 below visualises this comparison.

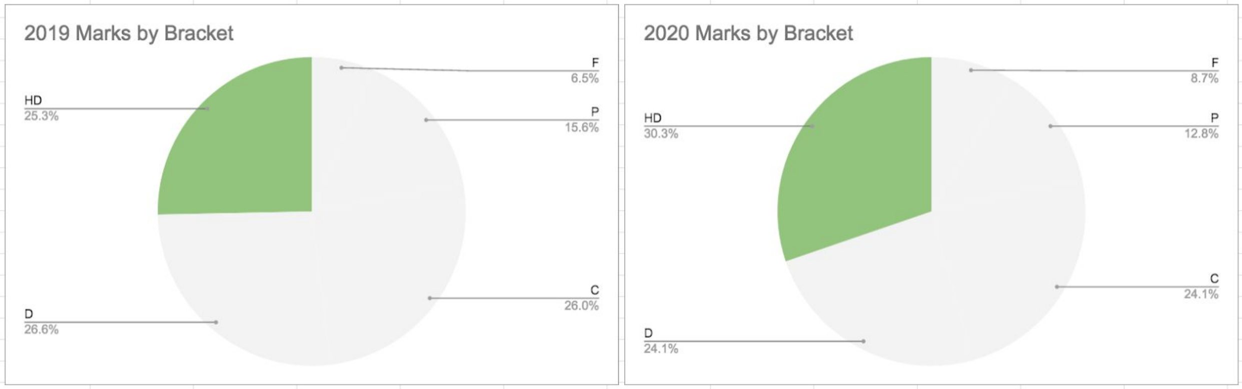

Figure 5.14: Challenge comparison by Assessment. While it's impossible to draw causal conclusions from the introduction of the meta-design prototype (because the 2019 and 2020 cohorts and learning environments were so different), there is a clear increase in HDs that may have been caused by the prototype.

If we assume that high distinction challenge would be perceived as of similar calibre as the high distinction candidates review by experts, there is an increased number of challenges available for curation that would that positively affects the encouragement state of students learning design programming with the presence of a meta-design framework to guide the creation of student made challenges. This is discussed further in the Chapter below.

Chapter 6

Discussion

In this chapter, we examine the results from the 5 phases of research to deepen our understanding of the research objectives (see Section 1.2). We've structured this chapter according to these objectives to explore findings, implications and limitations of our research. Section 6.1 details the exploration of our first objective, exploring effects of design patterns in challenges on student engagement and how this encourages cultivation of learning motivation. Section 6.2 covers the second research objective of understanding how students design learning activities, particularly online creative coding tasks. Section 6.3 discusses the third research objective of understanding how meta-design can effectively guide the student-authorship of creative coding OLTs. Design Principles are proposed at the end of each section. We consider these principles modular parts of a process that can harness the meta-design of instructional strategy through compatible design patterns to act as a catalyst of effective engagement to encourage learning motivation at scale.

6.1 Design Patterns in eLearning

Results indicate that students experience varying degrees of the encouragement state when engaging with OLTs. They suggest design patterns of OLTs encourage the cultivation of motivation to learn when they adhere to the following:

Well defined instructional strategy acts as the basis of design pattern use, minimum design patterns necessary to communicate this strategy and diversification of design patterns while adhering to the previous rules.

6.1.1 Syllogistic Form

During Phase 1, we expected the classification labels of design patterns to directly affect the positivity or negativity of the encouragement state. However, we discovered the differences in design pattern presence and configuration between challenges did not account for the magnitude of their differences in encouragement state. These differences are present in Table 6.1 (see section 6.1.2). In Phases 2 and 4 ("Semi-structured Interviews in Semester 1 and 2"), challenges that students associated with a positive encouragement state shared a consistency of instructional strategy. This consistency is twofold: the use of the design patterns available to communicate their instructional strategy in an effective way and the degree to which instructional strategy adhered to the form a syllogism. A syllogism is a form of argument that arrives at a conclusion based on two or more propositions. In Striker's Translation of Aristotle's *Prior Analytics* (2009), one form of a syllogism is defined as follows:

If A = B

And C = A

Then C = B

A well known example of this form is:

All men are mortal.

Socrates is a man.

Therefore, Socrates is mortal.

During Phases 2 and 4 of research, thematic notions emerged to support this idea.

P1 *"Before I start, uh, doing this code, I'd like to think first how do you draw these kinds of things."*

P25: *"I think in week one the fourth challenge was suddenly one with variables in functions and recreating art and that was totally impossible"*

P33: *"I think the color used so many lines to draw a colour the loop with colour was really interesting"*

Students associate negative encouragement with a challenge where there was a lack of explanation of the underlying concept in the mechanics of the code. Conversely, when challenges did explain the mechanics of the code, a positive encouragement state was associated with challenges. This explanation of code mechanics is an example of the *syllogistic form* required for instructional strategy to encourage the cultivation of motivation to learn. Table 6.1 below reveals this relationship between syllogistic form of instructional strategy and the encouragement state reflected through Likert score and challenge completion percentage.

Challenge	Week	Submission	Understanding	Enjoyment	Ease	Learning
Recreating Existing Design Part Two	1	7%	2.96	2.77	1.31	1.31
Using the Draw Loop	1	93%	3.98	4.09	3.60	3.60

Table 6.1: Likert score and challenge submission data. The top challenge does not follow a syllogistic form, has a low submission rate and has scores associated with a negative encouragement state. The bottom challenge does follow a syllogistic form, has a high submission rate and has scores associated with a high encouragement state.

As well as syllogistic explanation, results indicate challenges that provide an opportunity to recreate the logical argument put forth in the explanation through code were positively associated with the encouragement state.

Results indicate students enjoy this ability to recreate an argument through code regardless of the presence of syllogistic instructional strategy. However, this is most appreciated when paired with syllogistic instructional strategy. We believe this is due to the potential for the student to make the association between the explanation and recreation is increased when syllogistic instructional strategy is present.

Students also support the idea of syllogistic format that manifests in positive challenge as a step by step, broken down format or solutions in challenges. During semi structured interviews in Phases 2 and 4, the phrase “step by step” emerged spontaneously in conversations. They referred to both OLTs and the eLearning platform when discussing this Step by Step idea. Including solutions is also a necessary part of the OLT learning process as it provides the final stage in a syllogistic argument. As observed in the quotes below, students associate a step by step format with characteristics of a positive encouragement state.

P2: *"[on complex pattern making challenge] I think this one is my Favourite. We practice the, the nested for loops and also practiced the color and this one is step by step best that it's the step one, step two, step three and step four.*

So it's step by step best, is, it's not a gap from each step."

P5: *"So it could be more detailed and more step by step to move the course out."*

P5: *Maybe just step by step separate the eight pictures and give more explanation and give more hints.*

P20: *"I feel like a good challenge would be kind of maybe like a step by step kind of thing. Even written down in the code with the lines. The comments. I think that would be really good."*

P30: *"I think the good challenges are the ones where you have to do a step by step approach"*

In support of the Syllogistic Form, students in Phase 3 ("Focus Groups") expressed their views on including solutions. When asked "*Would you feel like there would be a detriment to your learning in that you were essentially given the answer?"* participants responded with "*No because in step one you'd have figured out.. that would be the challenge for step one."* Students believed the need to learn would be more important for them than the need to have the answer quickly.

Other responses include "*even if you get it right you might want to see how the tutors have done it because there might have been a better way. so even if you submit your own work you might want to see how other people do it. Just to improve your own work. It's not just about improving the final output."* This demonstrates a desire to improve coding technique through the presence of answers in the code.

Students also mentioned "*so I just fall behind and end up copying someone else's code to just get the work done and submit it which I thought was really.. was also really frustrating"*. This scenario recognises a negative encouragement state that emerges when answers aren't readily available. The student is in a rush to submit, copy the code and don't learn from the experience because they are frustrated.

This suggests there are encouraging benefits to including solutions as part of non assessable challenges. These results indicate by switching the collective goal of the course from "First to

Submit" to "First to Understand" the code, a more encouraging state is associated with all challenges within the eLearning platform.

This syllogistic format was used as the basis of structure for the Assessment Guide prototype. This is an OLT with the objective of understanding how to make OLTs.

Results from Phase 5 (Student-made Challenge Analysis) indicate the step by step format used as part of student challenges was associated with the encouragement state by experts.

E1: *"I really like the steps of this challenge - there's a good progression and I think it resolves to a nice and satisfying solution"*

E4: *"Clear step progression. Maybe the basics of ellipses could be skipped?"*

E4: *"The colored syntax breakdowns were really good. Hints should probably appear before the challenge."*

These examples of research findings indicate challenges with instructional strategy in syllogistic form are associated with a positive encouragement state by Students and Experts. Therefore, the design of OLTs should begin with the instructional strategy so as to not be hindered by the affordances of design patterns. We believe this guide could also apply to contexts outside our research environment, however further study would be required. We also believe the differences in how this instructional strategy manifests in other OLT contexts would be the relationship between the objective and design patterns and understanding the activities that most effectively hone skills which demonstrate efficacy in a discipline. This is based on our understanding of the student learning process when engaging in an OLT (see Section 6.2.1).

These findings for the first design guideline for design patterns in eLearning:

"*Effective instructional strategy follows a syllogistic format. The design of OLTs should begin by articulating instructional strategy* so as to not be hindered by the affordances of design patterns. "

6.1.2 Minimum Necessary Design

Table 6.1 below details design pattern classification results from Phase 1. By comparing averages of classification prevalence by the encouragement state of challenges archetypes, we can observe their association with the encouragement state.

Classification Name	Average +ve	Average -ve	Difference
Links	0.75	**2**	1.25

Text	7	**11.75**	4.75
Visuals	2	**2.75**	0.75
Goal	2.25	**2.5**	0.25
Steps	2.5	**5.25**	2.75
Code Diagram	**1**	0.75	-0.25
Code Editor	2.5	**3.75**	1.25

Table 6.1 The Average of Design Pattern Components in challenge archetypes of positive and negative encouragement state. The bolded column is the greater of the two: note that the challenges of a negative encouragement state have more of almost everything.

Text Components are an outlier. Negative challenge archetypes have on average (11.75/7 = 1.68) 1.68 times more text components than positive challenge . Code diagrams are also an outlier. In challenge archetypes, code diagrams were the only component where having more of them was on average associated with a positive encouragement state. Results indicate challenge with more components are less encouraging challenge with less components; less is more for the encouragement state. These findings are supported in thematic analysis from Phases 2 and 4 ("Semi-structured Interviews in Semester 1 and 2").

P6: *"[challenges] I was able to read it if it's not in a huge chunk of text. It's not as long."*

P25: *"Some of their (the challenges) sentences are just so long and don't make sense."*

P34: *"If it's too long I feel like it's not attractive but if it only had two I would really like it!*

This was supported by students during Phase 3 (Focus Groups) in that an excess of content is seen as immediately demotivating. As one focus group participant said "i*f you set an entire challenge for them they won't be able to solve it because it's going to look like too big of a task"*

Conversely results from Phase 2 ("Semester 1 Student Interviews") indicate when it comes to the amount of challenges in an eLearning platform, more is better.

P5: *"Maybe just adding more challenges inside of this noise function"*

P13: *"Offering more challenges is a good thing, but maybe not every student can finish all."*

P24: *"If you could have more challenges which are suited for us to practice outside home, not just tests part of class, that would be helpful."*

P30: *"After mid sem there wasn't as many challenges compared to the start of the semester I kind of wish there were more challenges just to challenges us a bit more"*

P34: *"The explaining was limited and the recommended challenges there's not too much. Maybe more is better."*

Results indicate students wanted more challenges for two reasons, either to catch up to the content in class or to learn further than what the content from class was teaching them.

This would suggest a greater number of smaller challenges would be an improvement on the current eLearning platform and that smaller challenges are associated with the encouragement state. These findings form the second design guideline for design patterns in eLearning:

Design Patterns of the same classification should be used as little as possible to communicate instructional strategy.

6.1.3 Perspective Diversification

In reference to table 6.1 it's unclear from Phase 1 results whether a balance of different design patterns makes a more encouraging challenge. Both positive and negative challenges have an even distribution of classifications: A majority in text and a balance of the other patterns. Phase 2 and 4 results indicate a more defined conclusion. Different components are useful for aspects of the learning process.

Visual Components are useful for explaining and understanding concepts and OLT objectives especially for students with english as a second language where large amounts of text are a barrier to learning. These Phase 2 and 4 ("Semi-structured Interviews in Semester 1 and 2") quotes explore student perspectives on the video component.

P2: *"I spend a lot of time on a YouTuber and like shiffman, the tutor recommend. Yeah that's*

good. And uh, I watch a lot of video from him."

P5: *"[on learning as ESL] so at least we understand what this course is talking about and we can a search lots of tutorial videos or resources online."*

P7: *"I found if I just go through so the course it's not enough. I have to watch some videos from youtube to improve my skills."*

Students perceived video as useful for understanding a concept because they can see what the code is meant to look like in a break down. This could be achieved through steps and a solution but in terms of minimal design patterns needed, this could all be achieved in one image component. It seems important to recommend or include video resources as part of the course to help students feel they aren't doing something wrong by learning through external resources.

From these results it seems a combination of video, steps and solution would be the most effective way to break down a concept and create an encouraging challenge.

Code Driven Components are useful for explaining code processes through pseudo-code and Code Editors are useful for applying knowledge and practically understanding the mechanics of code. Students have also said Code Driven Components are more engaging than blocks of text.

P1: *"More the interactive tutorial. Uh, instead of just, um, read through the slides."*

P2: *"[On complex pattern making challenge] I have lots of fun trying to change the color and see the different color combinations."*

P3: *"I really liked the method where you can like test your code and then you can immediately see the result."*

P25: *"Sometimes i see a lot of text and I see the task under and i'm not bothered to read the text i just try do the tasks straight away"*

This suggests that instead of just text components in steps, code driven components paired with an editor with code comments that explain how the code works would be an OLT format to encourage students to cultivate motivation to learn. By understanding this, our final guideline for Design patterns in eLearning was as follows: Using a variety of design patterns ensures better communication of OLT objectives and instructional strategy to students of all perspectives.

These findings for our third guidelines for design patterns in eLearning:

Using a variety of design patterns ensures better communication of OLT objectives and instructional strategy to students of all perspectives.

6.1.4 Design Guidelines

Based on our findings in this area that students need OLTs with instructional strategy that follows a syllogistic format, OLTs that design patterns as little as needs and OLTs that diversify design pattern use, we propose three design guidelines for future design of online learning tasks:

- *Effective instructional strategy follows a syllogistic format. The design of OLTs should begin by articulating instructional strategy* so as to not be hindered by the affordances of design patterns.
- *Design Patterns of the same classification should be used as little as possible to communicate instructional strategy.*
- *Using a variety of design patterns ensures better communication of OLT objectives and instructional strategy to students of all perspectives.*

6.2 Student Authored OLTs

Our results suggest that current students of creative coding are encouraged to learn from challenges created by prior students of creative coding. Their unique insight into the process of understanding a specific code mechanic or principles allows prior to craft instructional strategy that current students can relate to and better understand than instructional strategy written by experts. New students feel supported through the knowledge that with one semester's experience, prior students understand enough to create a challenge. We confirmed an aspect of the overjustification hypothesis (see) that dissonance between what makes a good challenge and the rubric leaves prior students making challenges conflicted about whether to prioritise a good lesson or a good assessment.

Prior students expressed concern over their own ability to create challenges and by ensuring them of a review process for their challenges were more confident to express their view of good instructional strategy: comforted they would not be passing on poor coding techniques. These results were the basis of our design guidelines for student authored OLTs. A working implementation of which could result in a system to design creative coding challenges at scale.

6.2.1 Personal Learning Processes

Results from Phases 2 and 4 ("Semi-structured Interviews in Semester 1 and 2") suggest that students associate a positive encouragement state with the idea of student challenges. Because the course coordinator of Design Programming did not include the student-made challenges that were available, our results refer to what Design Programming students thought about learning from prior students.

P15: *"I think it would actually give you reassurance that like you can by the end of these 13 weeks, that end of the semester, you'll get there."*

P16: *"It's like an incentive also for the students in the next class. If they're doing well, they can help contribute and give back to the next cohort. That's really cool."*

P17: *"I guess it would be a little bit more easier to understand if it is a student-made one, because they kind of are in a position where they might not know as much."*

P27: *"that's great because it if you could write a question that shows you really understand what you're doing"*

These findings suggest students felt motivated to learn by the prospect of teaching others, supported by the idea they could learn from prior students who were once in their position and positive towards the insights a previous student would have into the learning process. These questions were also asked of students from focus groups in Phase 3 ("Focus Groups") of evaluation. When asked *"How do we feel about the idea of teaching?"* Students responded *"I think it's something you can work towards. it will be fulfilling to allow other students to use your content to learn..You've worked hard yourself and it's fulfilling in that moment where you can share your work with other students I guess. It's rewarding"*

When considered amongst the group this was an agreed concept "*Yeah I agree I think it's better for students to teach students because we might not be as good as the tutors but if we can teach* *students how we learnt it it can give them a better perspective of how they can learn it. The tutors will understand things different to when we first start out."*

The students have identified what is known as threshold concepts: the idea that once a concept is understood one transforms ones perception of a body of knowledge (Cousin, 2006). These results indicate that because they have not passed this knowledge threshold, they are better equipped to explain a concept to other students. Therefore, their learning process is more valuable to other students than someone who has passed this threshold like a tutor.

This is also discussed by students comparing a view of their future self with a view of an authority figure and their preference to learn from their future self.

"*When I did design programming I thought they were very advanced…it felt unsolvable but I think it's quite comforting to know that if we design they were the people we were gonna be at the end of semester…it's easy to learn from somebody you could possibly be like that's a reachable goal whereas like if the professor of some major university is teaching you to code you'd be like 'I can never do that."*

In the results above the student feels the work of other students is more relatable because they don't see themselves as skilled as an authority figure like "the professor of some major university". Regardless of whether a coordinator is a professor or not, the image of them as an authority figure prevents students from having the confidence to complete lessons set out by an authority figure.

From the perspective of teaching there are two examples of student responses. One who is not confident in their skills and one who is.

F: *"Do you feel like you could teach p5 to programming students?"*

Ps: *" I was in the bunch of people who just did not understand p5 at all…dreaded this assignment because I didn't understand the topic of p5 …it feels weird that I have to teach someone something I don't completely understand. …this semester it's so much easier learning about HTML and CSS…I don't know if it's the perfect assignment for design programming students to teach other students because I think it's disadvantageous at times if you're not really good at p5"*

Ps: *"I wouldn't mind doing it. I mean I didn't struggle in the unit first of all. It's that people who just went through it [design programming course] understand what they struggled with and have more of an insight into the things that people who already understand take for granted..once you understand it it's just second nature but if you don't understand and no one teaches you because they say 'oh yes it just is the way it is' so if you don't have someone who's gone through the process recently*

> *or someone who remembers the process of learning it's often harder.. well not harder but often has little bits that you miss when you're tutoring students."*

The first participant believes that all design programming students would not be good teachers because they do not understand p5.js. This is at odd with the majority of findings from our results. Results indicate this perspective stems from a lack of confidence not from a lack of ability. The fact they regard the Web Design and Technologies course as an *'easier learning'* experience implies they had a poor learning experience during Design Programming. If they had a good learning experience perhaps they would probably be competent p5 coders.

The second participant conversely agrees with the majority of results that it is the lack of knowledge that, to a point, make prior design programming students better sources of instructional strategy than tutors as they have yet to pass the threshold of a concept.

These findings suggest students believe the learning process of prior students is more valuable than the current student because they remember how to learn better than tutors. While they believe it's possible a tutor will remember, they can't remember how they learnt these core principles because they've known how to program for so long. Some students feel they don't know enough about p5 to teach it and would be worried about passing on something they don't understand. They also feel this need to understand a language that wasn't marked in their assessment puts students who fell being in p5 at a disadvantage. These are covered in the design guidelines of 6.2.2 and 6.2.3.

Because these results from phases 2, 3 and 4 ("Semi Structured Interviews and Focus Groups") suggest the value students see in the learning process of prior students, prior students should guide the instructional strategy of OLTs for current students to increase their encouragement state. This forms the basis of the first Design Guidelines for student authored OLTs:

Prior Students should guide the instructional strategy of OLTs for current students through personal experience of the learning process.

6.2.2 Rubric Alignment

During focus groups in Phase 3 ("Focus Groups"), students asked where they should allocate their time when creating challenges. They understood that the Assessment Criteria (see Figure 4.21 in Section 4.5.2) involved a good learning experience but were concerned how much p5 they needed to know to provide this. One student asked the question "*are we doing the solution anywhere?*" and being a direct question about the rubric, the facilitator (me) needed to answer "*honestly it's up to you. I'll go through the rubric now because rubric interpretation is hard and that's something everyone has to get used to when they go to uni and the best way is just* *to check what the general vibe is and have a chat because that's what the tutors are going to be doing*." Because of the implicit nature of the rubric, there wasn't a yes or no answer to give. This was an example of when the misalignment of rubric can lead to confusion.

Another question asked was "what if our challenge covers multiple topics. Most things will use an array, most things will use a function so what if they need to learn both of those." A question that could be answered more explicitly but that wasn't covered in the assessment guide. This demonstrated the needs for these conversations to answer nuanced questions. This is covered further in Section 6.3.2. The answer to this was "*That's a great question. I think what you'd have to do is pick the one that is learnt last.*". And while this idea of curriculum mapping was covered briefly in the assessment guide, it was useful to have the opportunity to answer spontaneous questions in workshop sessions.

We believe this idea of rubric alignment could apply to many contexts outside of creative coding and, while logistically difficult to alter assessment criteria, could be useful in courses where a greater number of OLTs are needed that express the learning process of prior students to new students.

These findings form the basis of our second guideline for student authored OLTs:

If conducted in an assessable paradigm, rubrics should prioritise a student's communication of their personal learning process through their OLTs

6.2.3 Expert Review

In Phase 3 of evaluation ("Focus Groups"), students concern about their ability to pass lessons that wouldn't lead current students of design programming astray. When asked the question *"can we think of anything detrimental in this idea of student led teaching?"* students responded *"we're not very good at programming ourselves so our classes might be wrong and it might be little subtle things that we get from bad coding or bad logic. There are probably better ways that what we do"*. This was an insightful understanding of one's own limitations.

As well as this, students responded with a solution. *"there'd have to be a thorough review process because how we code might not be the most optimal way. So there has to be a middle person that checks through line by line each code and each technique that we use in our challenge"* this idea was agreed with amongst the group. "I agree with that. Just handing down wrong knowledge. Because I'm not strong at p5 and I wouldn't trust myself to just immediately help students with my project." Students also noticed that a combination of their learning process with expert review is a valuable thing; an allusion to the first guideline of student authored OLTs: *Prior Students should guide the instructional strategy of OLTs for current students through personal experience of the learning process.*

"I think that in this stage it's much more.. I don't know how to say it but I feel like I've got a lot to give but I'm insecure that I don't have enough knowledge to help other people...if there was a thorough review process I'd be happy to share"

From these findings, it was observed that students believed through a process of review, a student made challenge could be assured of teaching current students effective coding technique with the student learning process still guiding instructional strategy. Furthermore, student knowledge of the review process would make them feel reassured and 'Happy to share' their learning process with current students of design programming.

These findings form the basis of our third guidelines for student authored OLTs:

Students authored OLTs should be reviewed through subject matter expertise.

6.2.4 Design Guidelines

Based on our findings in this area that students design learning tasks effectively when they cultivate an explanation of their personal learning process, have a rubric aligned this cultivation and have OLTs reviewed by an expert, we propose three design guidelines for future student authorship of OLTs:

- *Prior Students should guide the instructional strategy of OLTs for current students through personal experience of the learning process.*
- *If conducted in an assessable paradigm, rubrics should prioritise a student's communication of their personal learning process through their OLTs.*
- *Students authored OLTs should be reviewed through subject matter expertise.*

6.3 Meta-design of Student Led Teaching

Results indicated that by giving Web Design and Technologies students guidance in creating a challenge they could better articulate their instructional strategy and communicate this strategy effectively through design patterns. Students were provided with an OLT for how to create a challenge i.e. the Assessment Guide (see Section 4.5) and workshops to facilitate the emergence of their learning process through collaboration (see Section 3.3). These results suggest that the degree to which a guiding OLT follows the guidelines from Section 6.1.4 and workshops implement guidelines from Section 6.2.4 that can be experienced by all students will determine the effectiveness of a meta-design as a catalyst of effective engagement to encourage learning motivation at scale.

6.3.1 A Guiding Resource

Results from Phase 2 and 4 ("Semi structured interviews in Semesters 1 and 2") indicate students orient themselves towards a goal using guiding resources. These can be both internal or external to the course.

P1: *"[process of completing challenge] I like to use the, um, p5.js reference"*

P2: *"I spend a lot of time on a YouTuber and like shiffman, the tutor recommended it. Yeah that's good. And uh, I watched a lot of videos from him."*

P3: *"[on the fibonacci challenge] In terms of finding out the specific parts, I had to do a lot of self research to understand because I still, I was still finding a lot of limitations."*

P5: *"I also watched the video by the Daniel Shiffman."*

P6: *"If I have no idea how the function works, I would look at the lecture notes. Also. I would um, get the p5.js reference site up to see how it was as well"*

P7: *"I just type p5.js in the YouTube and I just found lots of videos about how to deal with JavaScript."*

P9: *"a lot of the time the challenges doesn't like correlate with what the coding train is saying"*

P20: *"I watch a lot of YouTube videos working on the same code, and they do things differently, and I feel like I'm not supposed to do it that way because we aren't taught to do it that way."*

P22: *"Usually I watch the coding train or something like that, and the video is usually within 10 minutes and if I asked my tutors on Slack is, I don't know when he, or she will reply and I don't know how long the reply will be. There will be no visual elements or sound. So, yeah. Why not just watch YouTube."*

P23: *"For most of the time I finished the challenge and I often need to go to the other tutorial websites to get extra practice."*

P25: *"I asked them (tutors) what kind of resources I could use to help myself and they recommended Daniel Shiffman and other online things"*

P29: *"If it's something that i can find on youtube and teach myself then I can do it"*

We observed if no guiding resources are provided internal to the course students explore externally. This could lead to learning javascript that is not useful for their course. The risk of diversion from useful information indicates a need for guiding resources within the eLearning platform. There was also a lack of formal recommendation as to where to find these guiding resources. Tutors would assist specific students when they asked about resources. However, students did not identify a coordination of these resources that could be found without directly asking for them. This indicates a need for accessible guiding resources that students are intuitively aware of in the same way they know there are tutorials as part of the course.

Results from Phase 3 ("Focus Groups")indicate students associate the meta-design assessment guide with encouragement and support. It was observed this in in part because the guide adheres to design guidelines defined for design patterns in eLearning (see Section 6.1.4)

Ps: *"I actually found it really useful especially since last semester we didn't really get that much information on how to break the assessment down but i actually really like how it was broken down and there were different resources and if we wanted extra help there was extra help. so i really found it helpful."*

Ps: *"it's [title of the recipe in assessment guide] a good page i like it. i don't like the image because it lags and is very big but the instructions themselves are very helpful and the fact they have secriptions after them is nice and it's a good way of doing it. jump back to last semester where the navigation had a lot of back and forth I like how they're just here in this page. it's nice."*

Ps: *"yeah and the thing about that is because it's broken into parts there's no information overload when you're looking at it for the first time because you don't start getting stressed because you don't understand everything because it's one part at a time that leads on to the other part."*

Ps: *"I was just glad that we had all these resources. kind of made me less stressed out because it was so broken down and it didn't me too overwhelmed which was good."*

Ps: *"yeah it was helpful because most of the assessment was creating the website not really coding it and i wasn't really sure how to do that until this website [assessment guide]"*

Results from Phase 5 ("Student-Made Challenge Analysis") correlate an increase in high distinction marks when students are given a guiding resource in the form of an assessment guide. While it cannot be concluded whether this is dependent on the presence of an assessment guide, results of encouragement and support felt by students suggest it was a contributing factor. We can also assume from challenge heuristics that experts believe the student made challenges with a high distinction mark are suitable for use in the eLearning platform.

E1: *"Love the idea of having a solution but I think having it so readily available might make some students reliant on it."*

E1: *"I really like the steps of this challenge - there's a good progression and I think it resolves to a nice and satisfying solution"*

E1: *"I think the code snippets were really handy though and would help nudge students in the right direction"*

E2: *"The conceptual structure of this challenge ("making a neighbourhood") is a good conceit for exploring custom functions, and was applied well."*

E2: *"This challenge is complex, but that complexity is appropriate for the stated goal, and would make sense if delivered at an appropriate stage in an individual's learning process with p5.js."*

E2: *"This challenge is excellent. It's well-structured and offers good coverage of the topic. It also has a strong sense of humour in the examples which students may find engaging. It also smartly places the challenge solutions behind links so that students can seek them out if necessary, but they won't be accidentally spoiled."`*

E3: *"I like this one. Clear structure, clear purpose. Tasks could use a bit more commenting and scaffolding."*

E3: *"Pretty simple and straightforward, but nicely done."*

E3: *"Simple, straightforward from-the-ground-up explanation of arrays. Love the recreation of a simple geometric generative art piece, although I think they didn't quite get there on the 'puzzle' angle."*

E4: *"The 'join-the-dots' analogy is clear."*

E4: *"The colored syntax breakdowns were really good. Hints should probably appear before the challenge."*

E4: *"Overall clear progression through the events"*

E4: *"Short but clear, good goal orientation. Would be good to see use of memes throughout* *not just at the start and end."*

We observed that experts believed HD challenges weren't perfect but had a good foundation. This foundation could be combined with expert reviews (see Section 6.2.3), edit minor errors and add more OLTs to the eLearning platform. There was also a disagreement between students and tutors as to whether including solutions is useful for their learning process. We understand both arguments to be valid and conclude further testing is needed to observe it's effect on the programming efficacy.

While the assessment guide is correlated with an increase in HD challenges, expert support of HDs as candidates for the eLearning platform were unanimous across both 2019 and 2020 HD challenges. This begs the question why did the course coordinator of design programming not include student made challenges in Semester 1 of 2020. Our conclusion is they did not see the value in spending the time to make minor adjustments necessary to include them. We argue this is an ignorance or misunderstanding of student needs as results across all findings indicate the feelings of encouragement and support felt by students when provided with guiding resources in the form of OLTs and assessment guides.

These findings collectively indicate that A guiding resource adhering the previously establish guidelines for an effective OLT increases student encouragement stat, programming efficacy and the amount of student made challenges that can be used as part of the eLearning platform. They form the basis of the first guideline for the meta design of student led teaching:

Provide an accessible resource that guides student design of instructional strategy through well defined design patterns.

6.3.2 Collaborative Workshops

Results from Phase 2 and 4 (Semi-structured Interviews in Semesters 1 and 2) indicate students feel encouraged when they effectively recreate a logical syllogism i.e. figure something out, that has been presented to them in an OLT.

P1: *"[the challenges] the reason why I think it is enjoyable is that I want to, during this challenge I can feel kind of achievement or when I see this kind of, uh, solve the problem myself."*

P2: *"[on simpler challenges] if you can finish and you can have some like you can guess, obtain some achievement and*

uh, and uh, um, it's kind of friendly for some people who are having First contact with the coding."

P3: *"My main motivation is to just to get all the greens over here when I finished one challenge and I completed properly. Gives me like what motivation to go to the next one and finish that one too"*

P3: *"[on the fibonacci challenge] but once you got the finer subtle things it was very satisfying.*

Um, sometimes it's frustrating, but when I am, when I finished is very rewarding."

P20: *"[On what makes a good challenge] something really creative. It feels much more satisfying completing it. It also feels really satisfying if I can kind of tweak it a bit. Maybe like if I can easily change it around after I've completed it."*

P23: *"I found something interesting and I can go follow and then I like, I finished the challenge. I think I have some achievement."*

By recreating the OLT in code, their own form of logical syllogism, achievement is experienced by students. This is a characteristic associated with a positive encouragement state.

Results from Phase 2 and 4 (Semi-structured Interviews in Semesters 1 and 2) also indicate students are involved with helping others, being helped by others and support the idea of workshops.

P3: "Outside of class I just

normally work on the challenges and I help a lot on Slack."

P3: "[helping students] It's like a new thing to me because most of the time it's others helping me. So it's like something I always wanted to do"

P4: "I struggled with a few of the coding challenges. Um, most of them were answered by like my peers on Slack. Um, and also clarify some misunderstandings that I had about like some function concepts and stuff like that."

P6: "I think it would be really, really helpful if you guys have like some sort of programming help desk"

P7: "[on solving problems] Just facing some difficult question if you have can't solve it just ask people for helping. "

P10: "People are on Slack, so if I needed help, they're always there"

Results from Phase 3 indicate that in aspects of the Assessment Guide where the content was complex, encouragement state was negative.

F: “What do you think puzzle trick means?”

Ps: “Does it mean way to solve each step”

F: “Sort of. it's the collective term for the ways to solve each step”

Ps: “When I hear trick I think of and extra thing like in youtube videos when they introduce 'tips and tricks' it's like an aside whereas right now I think we're talking about the process or progress of solving the puzzle.”

Ps: “I don't think we even need an analogy something like 'a how to solve a puzzle'”

Ps: “ So we're essentially doing a reverse engineering.”

F: “Yeah that's right”

P: “It's kind of over complicating things with the puzzle”

F: “What makes you think that?”

P: “So we're actually the one teaching not the one learning so it's a bit misleading in that sense. I might understand it better using reverse engineering as opposed to a fancy analogy.”

During workshops this negative encouragement was alleviated through the guidance towards a reinterpretation of the content to better understand student-authorship of creative coding OLTs. This reinterpretation of content produces similar effects to instances of syllogism recreation: figuring out the code, observed in Phases 2 and 4 (Semi-structured Interviews in Semester 1 and 2). This similarity indicates that even when a meta-design resource negatively affects encouragement, facilitation of understanding a problem through workshops creates a positive encouragement state and an effective meta-design experience.

These findings form the basis of the second guideline for the meta-design of student led teaching:

The effectiveness of the meta-design framework is dependent on providing workshops that facilitate collaboration between students directed towards better understanding a task or problem.

6.3.3 Design Guidelines

Based on our findings in this area that students need resources and guidance in their interpretation, we propose two design guidelines for future meta-design of blended learning content:

- *Provide an accessible resource that guides student design of instructional strategy through well defined design patterns.*
- *The effectiveness of the meta-design framework is dependent on providing workshops that facilitate collaboration between students directed towards better understanding a task or problem.*

Chapter 7

Conclusion

This research aimed to explore the relationship between creative coding OLTs and the encouragement state: a broad term we used to define the frame of mind in which students cultivate a motivation to learn. We did this through enquiry into three areas. The first was the effects of design patterns in creative coding online learning tasks (OLTs) on student engagement and how this encourages cultivation of learning motivation. The second was how students design learning activities, particularly online creative coding tasks. The third was the ways meta-design could guide the creation of student made challenges. This exploration was conducted as part of a larger research team that was considering the design of eLearning platforms in tandem with this research. Together, the team collected data for collaborative analysis to deepen the understanding of all research objectives.

We explored these objectives through the conceptualisation, design, development, implementation and evaluation of technological artefacts: an interpretation of Research through Design. These technological artefacts consisted of a redesigned eLearning platform, online learning tasks classified through design patterns and a meta-design framework to guide prior students of design programming to create challenges for current students.

The results of our research provides three areas of evidence. The first is the association between a positive encouragement state and OLTs with instructional strategy in a syllogistic form that uses design patterns effectively as a medium of communication. The second is student perception of the value of a prior student's learning process and a tutor's review of this process, particularly to guide the instructional strategy within an OLT. The third is the effectiveness of meta-design as a guide for student-made challenges when combining accessibility to a resource that guides the creation of student-made challenges with workshops that facilitate collaboration between students to better understand their personal creation process.

Indications of this research include observable improvement in programming efficacy for students who engage in meta-design frameworks. While an inconclusive observation outside the scope of research objectives, this does imply an avenue for future work: the exploration of the programming efficacy within a meta-design framework: the goal of which is the collective improvement of coding skills amongst a cohort.

This research has met the objectives involved in the relationship between OLTs and the encouragement through the acquisition of insights from evidence in results. These insights have manifested and can continue to manifest through iteration of the technological artefacts involved in this research and design guidelines to guide this iteration and the emergence of meta-design frameworks in similar contexts. Ultimately, this will guide online learning tasks to be collaborative, accessible and social through the creation of design patterns specific to the context of skills and disciplines. This implies a collective formation of eLearning experiences that catalyse the learning process as a valuable tool to provide understanding that encourages the cultivation of motivation to learn at scale.

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Zimmerman, J., Stolterman, E., & Forlizzi, J. (2010, August). An analysis and critique of Research through Design: towards a formalization of a research approach. In proceedings of the 8th ACM conference on designing interactive systems (pp. 310-319).

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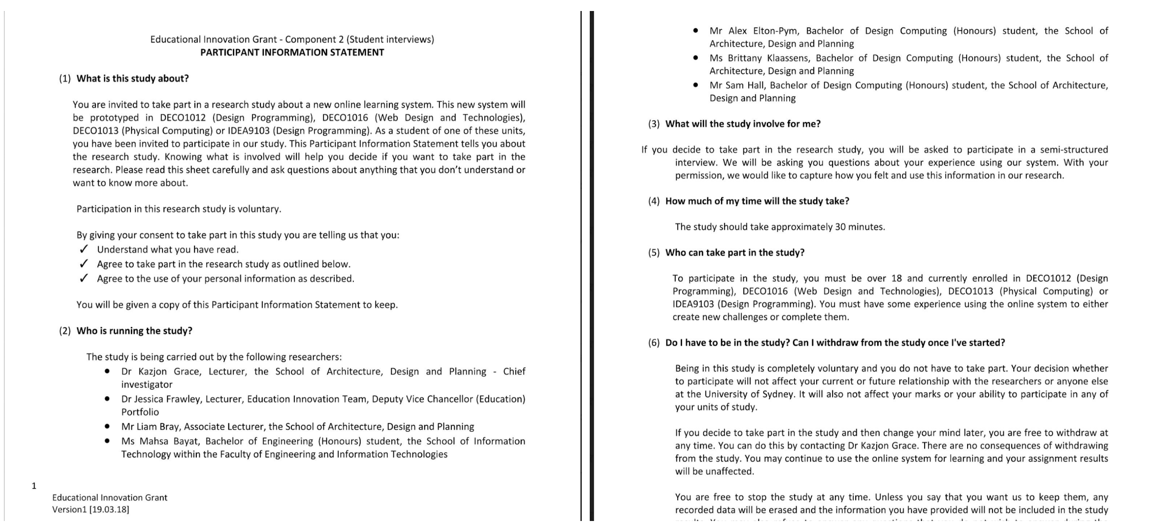
Appendix

Ethics Protocol

Project Title	Creative Coding Challenge: Student-generated self-directed learning
Project Number	2018/442

Participant Information and Consent Form

These can be found in auxiliary materials and are titled "participant-information-statement.docx" and "participant-consent-form.docx" respectively.



Educational Innovation Grant - Component 2 (Student interviews)
PARTICIPANT INFORMATION STATEMENT

(1) **What is this study about?**

You are invited to take part in a research study about a new online learning system. This new system will be prototyped in DECO1012 (Design Programming), DECO1016 (Web Design and Technologies), DECO1013 (Physical Computing) or IDEA9103 (Design Programming). As a student of one of these units, you have been invited to participate in our study. This Participant Information Statement tells you about the research study. Knowing what is involved will help you decide if you want to take part in the research. Please read this sheet carefully and ask questions about anything that you don't understand or want to know more about.

Participation in this research study is voluntary.

By giving your consent to take part in this study you are telling us that you:
- ✓ Understand what you have read.
- ✓ Agree to take part in the research study as outlined below.
- ✓ Agree to the use of your personal information as described.

You will be given a copy of this Participant Information Statement to keep.

(2) **Who is running the study?**

The study is being carried out by the following researchers:
- Dr Kazjon Grace, Lecturer, the School of Architecture, Design and Planning - Chief investigator
- Dr Jessica Frawley, Lecturer, Education Innovation Team, Deputy Vice Chancellor (Education) Portfolio
- Mr Liam Bray, Associate Lecturer, the School of Architecture, Design and Planning
- Ms Mahsa Bayat, Bachelor of Engineering (Honours) student, the School of Information Technology within the Faculty of Engineering and Information Technologies

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Educational Innovation Grant
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- Mr Alex Elton-Pym, Bachelor of Design Computing (Honours) student, the School of Architecture, Design and Planning
- Ms Brittany Klaassens, Bachelor of Design Computing (Honours) student, the School of Architecture, Design and Planning
- Mr Sam Hall, Bachelor of Design Computing (Honours) student, the School of Architecture, Design and Planning

(3) **What will the study involve for me?**

If you decide to take part in the research study, you will be asked to participate in a semi-structured interview. We will be asking you questions about your experience using our system. With your permission, we would like to capture how you felt and use this information in our research.

(4) **How much of my time will the study take?**

The study should take approximately 30 minutes.

(5) **Who can take part in the study?**

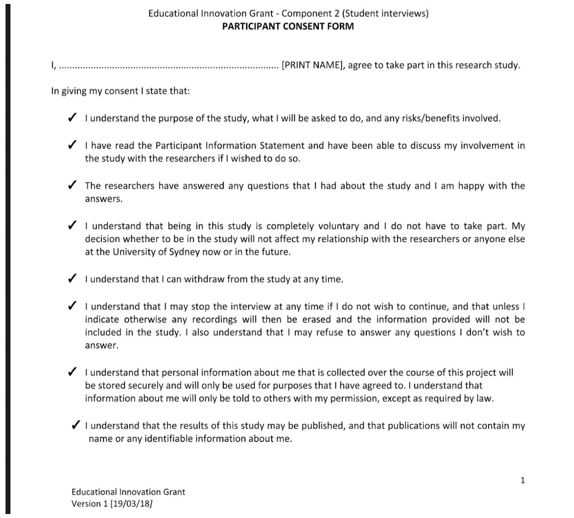
To participate in the study, you must be over 18 and currently enrolled in DECO1012 (Design Programming), DECO1016 (Web Design and Technologies), DECO1013 (Physical Computing) or IDEA9103 (Design Programming). You must have some experience using the online system to either create new challenges or complete them.

(6) **Do I have to be in the study? Can I withdraw from the study once I've started?**

Being in this study is completely voluntary and you do not have to take part. Your decision whether to participate will not affect your current or future relationship with the researchers or anyone else at the University of Sydney. It will also not affect your marks or your ability to participate in any of your units of study.

If you decide to take part in the study and then change your mind later, you are free to withdraw at any time. You can do this by contacting Dr Kazjon Grace. There are no consequences of withdrawing from the study. You may continue to use the online system for learning and your assignment results will be unaffected.

You are free to stop the study at any time. Unless you say that you want us to keep them, any recorded data will be erased and the information you have provided will not be included in the study



Educational Innovation Grant - Component 2 (Student interviews)
PARTICIPANT CONSENT FORM

I, ... [PRINT NAME], agree to take part in this research study.

In giving my consent I state that:

- ✓ I understand the purpose of the study, what I will be asked to do, and any risks/benefits involved.
- ✓ I have read the Participant Information Statement and have been able to discuss my involvement in the study with the researchers if I wished to do so.
- ✓ The researchers have answered any questions that I had about the study and I am happy with the answers.
- ✓ I understand that being in this study is completely voluntary and I do not have to take part. My decision whether to be in the study will not affect my relationship with the researchers or anyone else at the University of Sydney now or in the future.
- ✓ I understand that I can withdraw from the study at any time.
- ✓ I understand that I may stop the interview at any time if I do not wish to continue, and that unless I indicate otherwise any recordings will then be erased and the information provided will not be included in the study. I also understand that I may refuse to answer any questions I don't wish to answer.
- ✓ I understand that personal information about me that is collected over the course of this project will be stored securely and will only be used for purposes that I have agreed to. I understand that information about me will only be told to others with my permission, except as required by law.
- ✓ I understand that the results of this study may be published, and that publications will not contain my name or any identifiable information about me.

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Phase 1 Materials

Challenge Feedback Data

Figure 9.1 below is an image of the spreadsheet of student feedback for challenges in Semester 1 of 2020. This was used in Phase 1 of Research (see Section 3.1). A csv file of this data can be found in the */phase_1* folder of auxiliary materials and is titled “challenge_feedback_data.csv”.

	A	B	C	D	E	F	G	H	I
1	Participant ID	Challenge Name	Understanding	Enjoyment	Ease	Learning	Epoch/Unix	TimeStamp	Week
2	345	my-first-sketch	4	5	3	5	1584785543593	21 Mar 2020	1
3	339	my-first-sketch	4	4	4	4	1584793221354	21 Mar 2020	1
4	346	my-first-sketch	5	5	5	5	1584803850573	21 Mar 2020	1
5	346	using-the-draw-lo	5	5	5	5	1584803866724	21 Mar 2020	1
6	340	introduction-to-va	4	4	4	4	1584839629282	22 Mar 2020	1
7	266	introduction-to-va	4	4	4	4	1584846306126	22 Mar 2020	1
8	331	my-first-sketch	4	4	3	5	1584850114892	22 Mar 2020	1
9	329	my-first-sketch	5	5	5	5	1584850219640	22 Mar 2020	1
10	331	using-the-draw-lo	4	4	4	3	1584850337013	22 Mar 2020	1
11	331	basics-of-drawing	4	4	3	4	1584850357426	22 Mar 2020	1
12	331	recreating-existir	5	5	3	4	1584850388855	22 Mar 2020	1
13	329	using-the-draw-lo	5	5	5	5	1584853163082	22 Mar 2020	1
14	329	basics-of-drawing	5	5	5	5	1584854839696	22 Mar 2020	1
15	333	basics-of-drawing	3	3	3	3	1584855215425	22 Mar 2020	1
16	248	my-first-sketch	5	5	5	5	1584856364669	22 Mar 2020	1
17	248	using-the-draw-lo	5	5	5	5	1584856569297	22 Mar 2020	1
18	347	my-first-sketch	5	5	5	5	1584866188706	22 Mar 2020	1
19	347	using-the-draw-lo	5	5	5	5	1584866567673	22 Mar 2020	1
20	32	introduction-to-va	0	0	0	0	1584867834943	22 Mar 2020	1
21	347	basics-of-drawing	5	4	3	5	1584870088743	22 Mar 2020	1
22	63	my-first-sketch	4	4	3	4	1584872553665	22 Mar 2020	1
23	329	introduction-to-va	5	5	5	5	1584872916902	22 Mar 2020	1
24	264	recreating-existir	5	3	3	3	1584874049204	22 Mar 2020	1
25	63	using-the-draw-lo	5	4	4	4	1584874468618	22 Mar 2020	1
26	63	basics-of-drawing	4	4	4	4	1584878456590	22 Mar 2020	1
27	342	introduction-to-va	3	3	3	3	1584890613398	22 Mar 2020	1
28	291	using-the-draw-lo	5	5	5	5	1584927693840	23 Mar 2020	1
29	348	basics-of-drawing	3	3	3	3	1584931915386	23 Mar 2020	1
30	349	my-first-sketch	5	5	3	5	1584934847489	23 Mar 2020	1
31	333	using-the-draw-lo	4	4	4	4	1584935395759	23 Mar 2020	1
32	248	basics-of-drawing	5	5	5	5	1584939060995	23 Mar 2020	1
33	248	introduction-to-va	5	5	5	5	1584939104052	23 Mar 2020	1
34	329	recreating-existir	5	5	5	5	1584939392963	23 Mar 2020	1
35	189	basics-of-drawing	5	5	5	5	1584945757053	23 Mar 2020	1
36	350	my-first-sketch	5	5	5	5	1584951193559	23 Mar 2020	1
37	350	basics-of-drawing	5	5	5	5	1584954376691	23 Mar 2020	1
38	350	using-the-draw-lo	5	5	5	5	1584955678963	23 Mar 2020	1
39	349	using-the-draw-lo	5	5	5	5	1584957630535	23 Mar 2020	1
40	349	basics-of-drawing	5	1	5	5	1584958998843	23 Mar 2020	1
41	202	basics-of-drawing	5	5	4	4	1584960322470	23 Mar 2020	1
42	349	introduction-to-va	5	5	5	5	1584961307133	23 Mar 2020	1
43	341	introduction-to-va	4	3	3	4	1584963436582	23 Mar 2020	1
44	339	using-the-draw-lo	4	4	4	4	1584992049133	23 Mar 2020	1
45	339	basics-of-drawing	4	4	4	4	1584993143021	23 Mar 2020	1
46	339	introduction-to-va	4	4	4	4	1584996660922	23 Mar 2020	1
47	339	recreating-existir	4	4	4	4	1584998326148	23 Mar 2020	1
48	8	my-first-sketch	3	3	3	3	1585009466778	24 Mar 2020	1
49	157	introduction-to-va	5	5	5	5	1585012244674	24 Mar 2020	1
50	310	my-first-sketch	3	4	3	4	1585013413687	24 Mar 2020	1

Figure 9.1: Challenge Feedback Data from Semester 1 2020 of Design Programming Students

Challenge Completion Data

Figure 9.2 below is an image of the spreadsheet of student completion rate of challenges in Semester 1 of 2020. This was used in Phase 1 of Research (see Section 3.1). A csv file of this data can be found in the */phase_1* folder of auxiliary materials and is titled "challenge_completion_data.csv".

	A	B	C
1	name	Week	Popularity
2	basics-of-drawing	1	357
3	introduction-to-va	1	189
4	my-first-sketch	1	379
5	recreating-existir	1	107
6	recreating-existir	1	26
7	using-relative-valu	1	178
8	using-the-draw-lo	1	369
9	complex-pattern-	2	83
10	introduction-to-cc	2	355
11	introduction-to-fo	2	339
12	loops-with-color	2	159
13	nested-for-loops	2	301
14	patterns-using-lo	2	133
15	easing	3	311
16	fibonacci	3	14
17	introduction-to-ra	3	325
18	introduction-to-th	3	309
19	more-easing-anir	3	18
20	sin-and-cos	3	84
21	applying-the-weir	4	282
22	assignment-1	4	313
23	refactor-with-func	4	238

Figure 9.2: Challenge Completion Data from Semester 1 2020 of Design Programming Students

Classifications of Archetypal Challenges

Table 9.1 below provides the definitions of Classifications of design patterns observed in archetypal challenges. The numerical code used during classification of challenges is also provided

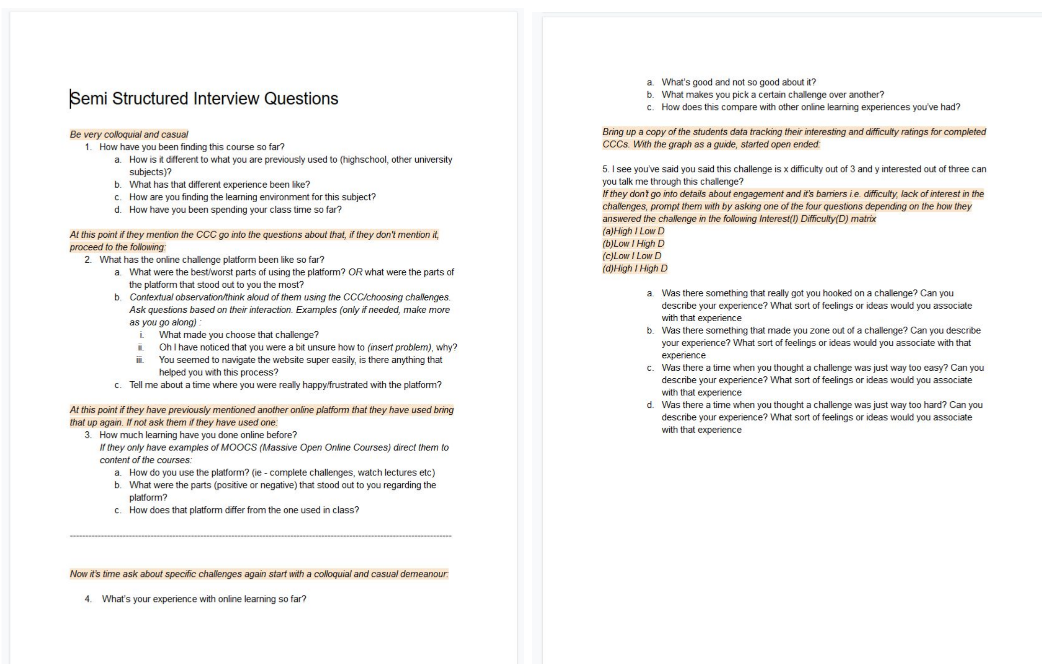
Code	Name	Description
1	Navigation Components	A component dedicated to the navigation between pages of an eLearning platform
2	Community Support Component	A component that interacts with an online social community system built for the eLearning platform
3	Links to Additional Content	Links to other resources that are related to the OLT objective. Either internal or external to the eLearning platform.
4	Text-Driven Component	A component to display text providing instructional strategy.
5	Visually-Driven Component	A component to display images or videos providing instructional strategy
6	Goal Orientation Component	A component to define the OLT objective
7	Task-Based Structure	A component to step a user through the sub tasks involved in completing OLT objective
8	Code-Driven Component	A component to display pseudo code or code snippets providing instructional strategy
9	Code Editing Component	A component to edit code within the OLT that leads to the completion of the OLT objective

Table 9.1: Definitions of Design Pattern Classifications

Phase 2 and 4 Materials

Round One Prompt Points

Figure 9.2 below is an image of the prompt points used for round one of semi structured This was used in Phase 1 of Research (see Section 3.1).



Semi Structured Interview Questions

Be very colloquial and casual

1. How have you been finding this course so far?
   a. How is it different to what you are previously used to (highschool, other university subjects)?
   b. What has that different experience been like?
   c. How are you finding the learning environment for this subject?
   d. How have you been spending your class time so far?

At this point if they mention the CCC go into the questions about that, if they don't mention it, proceed to the following:

2. What has the online challenge platform been like so far?
   a. What were the best/worst parts of using the platform? *OR* what were the parts of the platform that stood out to you the most?
   b. *Contextual observation/think aloud of them using the CCC/choosing challenges. Ask questions based on their interaction. Examples (only if needed, make more as you go along) :*
      i. What made you choose that challenge?
      ii. Oh I have noticed that you were a bit unsure how to *(insert problem)*, why?
      iii. You seemed to navigate the website super easily, is there anything that helped you with this process?
   c. Tell me about a time where you were really happy/frustrated with the platform?

At this point if they have previously mentioned another online platform that they have used bring that up again. If not ask them if they have used one:

3. How much learning have you done online before?
   If they only have examples of MOOCS (Massive Open Online Courses) direct them to content of the courses:
   a. How do you use the platform? (ie - complete challenges, watch lectures etc)
   b. What were the parts (positive or negative) that stood out to you regarding the platform?
   c. How does that platform differ from the one used in class?

Now it's time ask about specific challenges again start with a colloquial and casual demeanour:

4. What's your experience with online learning so far?
   a. What's good and not so good about it?
   b. What makes you pick a certain challenge over another?
   c. How does this compare with other online learning experiences you've had?

Bring up a copy of the students data tracking their interesting and difficulty ratings for completed CCCs. With the graph as a guide, started open ended:

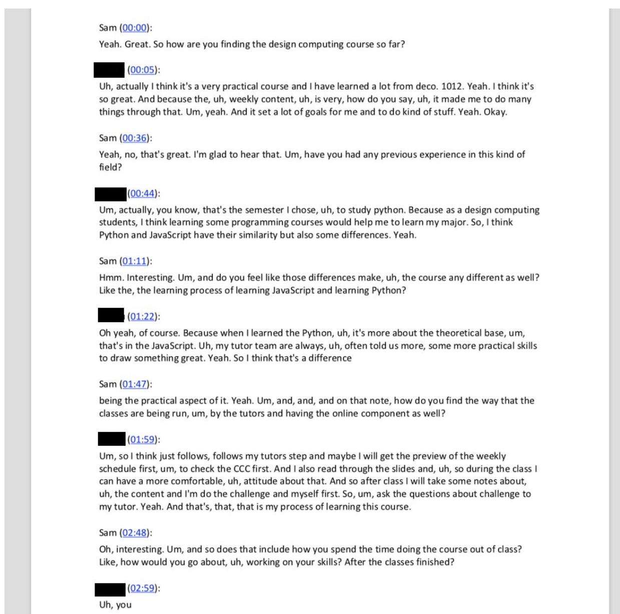
5. I see you've said you said this challenge is x difficulty out of 3 and y interested out of three can you talk me through this challenge?
If they don't go into details about engagement and it's barriers i.e. difficulty, lack of interest in the challenges, prompt them with by asking one of the four questions depending on the how they answered the challenge in the following Interest(I) Difficulty(D) matrix
(a)High I Low D
(b)Low I High D
(c)Low I Low D
(d)High I High D

   a. Was there something that really got you hooked on a challenge? Can you describe your experience? What sort of feelings or ideas would you associate with that experience
   b. Was there something that made you zone out of a challenge? Can you describe your experience? What sort of feelings or ideas would you associate with that experience
   c. Was there a time when you thought a challenge was just way too easy? Can you describe your experience? What sort of feelings or ideas would you associate with that experience
   d. Was there a time when you thought a challenge was just way too hard? Can you describe your experience? What sort of feelings or ideas would you associate with that experience

Figure 9.2: Prompt points used for round one of semi structured interviews.

Round One Transcripts

Figure 9.3 below is an image of a transcript from round one of semi structured interviews. This was used in Phase 1 of Research (see Section 3.2). These have been stored as pdfs and can be found in the at /phase_2_and_4/round-one folder of auxiliary materials.



Sam (00:00):

Yeah. Great. So how are you finding the design computing course so far?

[redacted] (00:05):

Uh, actually I think it's a very practical course and I have learned a lot from deco. 1012. Yeah. I think it's so great. And because the, uh, weekly content, uh, is very, how do you say, uh, it made me to do many things through that. Um, yeah. And it set a lot of goals for me and to do kind of stuff. Yeah. Okay.

Sam (00:36):

Yeah, no, that's great. I'm glad to hear that. Um, have you had any previous experience in this kind of field?

[redacted] (00:44):

Um, actually, you know, that's the semester I chose, uh, to study python. Because as a design computing students, I think learning some programming courses would help me to learn my major. So, I think Python and JavaScript have their similarity but also some differences. Yeah.

Sam (01:11):

Hmm. Interesting. Um, and do you feel like those differences make, uh, the course any different as well? Like the, the learning process of learning JavaScript and learning Python?

[redacted] (01:22):

Oh yeah, of course. Because when I learned the Python, uh, it's more about the theoretical base, um, that's in the JavaScript. Uh, my tutor team are always, uh, often told us more, some more practical skills to draw something great. Yeah. So I think that's a difference

Sam (01:47):

being the practical aspect of it. Yeah. Um, and, and, and on that note, how do you find the way that the classes are being run, um, by the tutors and having the online component as well?

[redacted] (01:59):

Um, so I think just follows, follows my tutors step and maybe I will get the preview of the weekly schedule first, um, to check the CCC first. And I also read through the slides and, uh, so during the class I can have a more comfortable, uh, attitude about that. And so after class I will take some notes about, uh, the content and I'm do the challenge and myself first. So, um, ask the questions about challenge to my tutor. Yeah. And that's, that, that is my process of learning this course.

Sam (02:48):

Oh, interesting. Um, and so does that include how you spend the time doing the course out of class? Like, how would you go about, uh, working on your skills? After the classes finished?

[redacted] (02:59):

Uh, you

Figure 9.3: A transcript from round one of semi structured interviews.

Round Two Prompt Points

Figure 9.4 below is an image of the prompt points used for round two of semi structured. This was used in Phase 2 of Research (see Section 3.2).

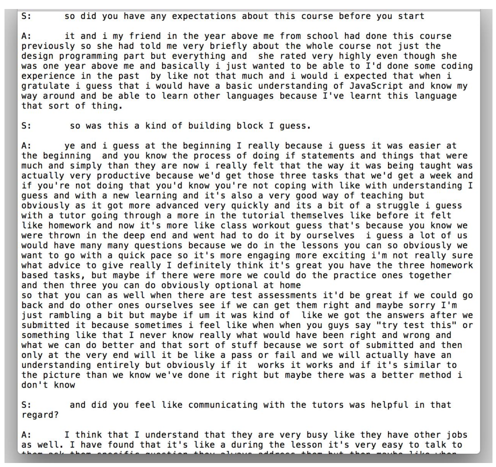
Combined qs

1. **Did you have any expectations about this course before you started?**
    a. If yes, how did the reality compare to your expectations?
    b. If no, ask more specific question (ie - level of difficulty, amount of work, platform layout, delivery of material etc)
2. **Have you found communicating with your tutors helpful?**
    - Can you give me an example of that communication?
    - What about outside of class time?
    - If no, what deters
3. **Have you found communicating with your classmates helpful?**
    - Can you give me an example of that communication?
    - What about outside of class time?
    - If no, what deters?
4. **What do you think makes a good challenge?**
    - Did you notice that there were challenges written by students
    - Did it feel different doing a student written challenge. How so?
5. **Have you ever done a challenge that wasn't covered in class?**
    a. If no, why?
    b. If yes, why?
6. **Did you do challenges where you had to make something new i.e. had multiple right answers/different visual outcomes? How so?**
    - How did you feel about this way of learning? Did you enjoy it/hate it/boring
    - How did you know when you were done? How did you decide when to stop

Figure 9.4: Prompt points used for round two of semi structured interviews.

Round Two Transcripts

Figure 9.5 below is an image of a transcript from round two of semi structured interviews..This was used in Phase 2 of Research (see Section 3.2). These have been stored as txt files and can be found in the at /phase_2_and_4/round-two folder of auxiliary materials.



S: so did you have any expectations about this course before you start

A: it and i my friend in the year above me from school had done this course previously so she had told me very briefly about the whole course not just the design programming part but everything and she rated very highly even though she was one year above me and basically i just wanted to be able to I'd done some coding experience in the past by like not that much and i would i expected that when i gratulate i guess that i would have a basic understanding of JavaScript and know my way around and be able to learn other languages because I've learnt this language that sort of thing.

S: so was this a kind of building block I guess.

A: ye and i guess at the beginning I really because i guess it was easier at the beginning and you know the process of doing if statements and things that were much and simply than they are now i really felt that the way it was being taught was actually very productive because we'd get those three tasks that we'd get a week and if you're not doing that you'd know you're not coping with like with understanding I guess and with a new learning and it's also a very good way of teaching but obviously as it got more advanced very quickly and its a bit of a struggle i guess with a tutor going through a more in the tutorial themselves like before it felt like homework and now it's more like class workout guess that's because you know we were thrown in the deep end and went had to do it by ourselves i guess a lot of us would have many many questions because we do in the lessons you can so obviously we want to go with a quick pace so it's more engaging more exciting i'm not really sure what advice to give really I definitely think it's great you have the three homework based tasks, but maybe if there were more we could do the practice ones together and then three you can do obviously optional at home
so that you can as well when there are test assessments it'd be great if we could go back and do other ones ourselves see if we can get them right and maybe sorry I'm just rambling a bit but maybe if um it was kind of like we got the answers after we submitted it because sometimes i feel like when when you guys say "try test this" or something like that I never know really what would have been right and wrong and what we can do better and that sort of stuff because we sort of submitted and then only at the very end will it be like a pass or fail and we will actually have an understanding entirely but obviously if it works it works and if it's similar to the picture than we know we've done it right but maybe there was a better method i don't know

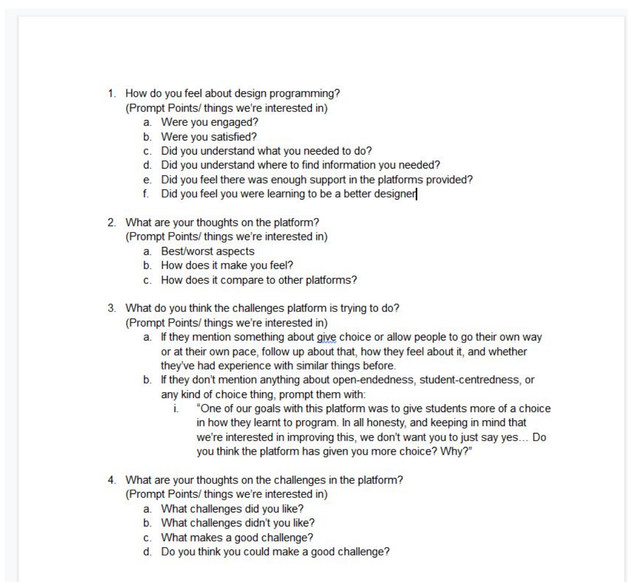
S: and did you feel like communicating with the tutors was helpful in that regard?

A: I think that I understand that they are very busy like they have other jobs as well. I have found that it's like a during the lesson it's very easy to talk to

Figure 9.5: A transcript from round two of semi structured interviews.

Round Three Prompt Points

Figure 9.6 below is an image of the prompt points used for round three of semi structured. This was used in Phase 4 of Research (see Section 3.4).

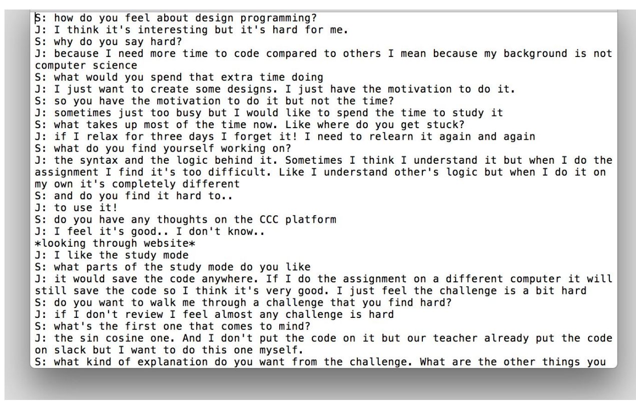


1. How do you feel about design programming?
   (Prompt Points/ things we're interested in)
   a. Were you engaged?
   b. Were you satisfied?
   c. Did you understand what you needed to do?
   d. Did you understand where to find information you needed?
   e. Did you feel there was enough support in the platforms provided?
   f. Did you feel you were learning to be a better designer
2. What are your thoughts on the platform?
   (Prompt Points/ things we're interested in)
   a. Best/worst aspects
   b. How does it make you feel?
   c. How does it compare to other platforms?
3. What do you think the challenges platform is trying to do?
   (Prompt Points/ things we're interested in)
   a. If they mention something about give choice or allow people to go their own way or at their own pace, follow up about that, how they feel about it, and whether they've had experience with similar things before.
   b. If they don't mention anything about open-endedness, student-centredness, or any kind of choice thing, prompt them with:
      i. "One of our goals with this platform was to give students more of a choice in how they learnt to program. In all honesty, and keeping in mind that we're interested in improving this, we don't want you to just say yes… Do you think the platform has given you more choice? Why?"
4. What are your thoughts on the challenges in the platform?
   (Prompt Points/ things we're interested in)
   a. What challenges did you like?
   b. What challenges didn't you like?
   c. What makes a good challenge?
   d. Do you think you could make a good challenge?

Figure 9.6: Prompt points used for round three of semi structured interviews.

Round Three Transcripts

Figure 9.7 below is an image of a transcript from round three of semi structured interviews..This was used in Phase 4 of Research (see Section 3.4). These have been stored as pdfs and.txt files and can be found in the at /phase_2_and_4/round-three folder of auxiliary materials.



S: how do you feel about design programming?
J: I think it's interesting but it's hard for me.
S: why do you say hard?
J: because I need more time to code compared to others I mean because my background is not computer science
S: what would you spend that extra time doing
J: I just want to create some designs. I just have the motivation to do it.
S: so you have the motivation to do it but not the time?
J: sometimes just too busy but I would like to spend the time to study it
S: what takes up most of the time now. Like where do you get stuck?
J: if I relax for three days I forget it! I need to relearn it again and again
S: what do you find yourself working on?
J: the syntax and the logic behind it. Sometimes I think I understand it but when I do the assignment I find it's too difficult. Like I understand other's logic but when I do it on my own it's completely different
S: and do you find it hard to..
J: to use it!
S: do you have any thoughts on the CCC platform
J: I feel it's good.. I don't know..
looking through website
J: I like the study mode
S: what parts of the study mode do you like
J: it would save the code anywhere. If I do the assignment on a different computer it will still save the code so I think it's very good. I just feel the challenge is a bit hard
S: do you want to walk me through a challenge that you find hard?
J: if I don't review I feel almost any challenge is hard
S: what's the first one that comes to mind?
J: the sin cosine one. And I don't put the code on it but our teacher already put the code on slack but I want to do this one myself.
S: what kind of explanation do you want from the challenge. What are the other things you

Figure 9.7: Prompt points used for round three of semi structured interviews.

Phase 2 and 4 Thematic Analysis Data

Figure 9.8 below is an image of a dataset. This dataset contains fractured transcriptions from semi structured interviews that have been thematically coded. This dataset was used in Phases 2 and 4 of Research (see Sections 3.2 and 3.4). This dataset can be found in the at /phase_2_and_4/round-three folder of auxiliary materials.

A csv file of this data can be found in the */phase_2_and_4* folder of auxiliary materials and is titled "rounds-1-2-and-3-thematic-analysis-data.csv".

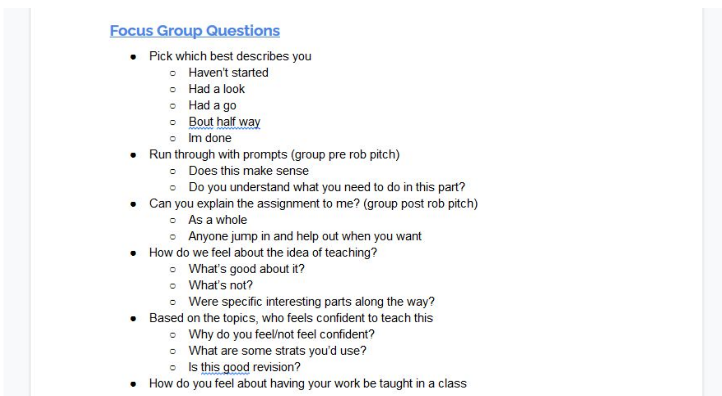
	A	B	C	D	E
1	ID	Quote	Theme Tag	Theme 2 Tag	
2	P1	actually I think it	Learning Reflection		
3	P1	I have learned a	Learning Reflection		
4	P1	And because the things through tl	Learning Opportunity		
5	P1	So, I think Python and Java	Experience with Code		
6	P1	when I learned t that's in the Java to draw somethi	Experience with Code		
7	P1	follows my tutor schedule first, ui	Student Workflows		
8	P1	I also read throu can have a more	Student Workflows		
9	P1	after class I will t uh, the content a	Student Workflows		
10	P1	actually I spend me to do this.	Fail fear		
11	P1	Uh, it's a little bi	Difficulty Progressing		
12	P1	basically the first or four [tags] in	Challenge Categories		
13	P1	when I do some course, uh, it's a Yeah. and norma	Clarification		
14	P1	[creative coding that discipline to	Motivating Aspects		
15	P1	[creative coding	Concept Understanding		
16	P1	[creative coding can just follow tl	Step by Step		
17	P1	[creative coding and the advance	Challenge Categories		

Figure 9.8: Fractured Transcriptions from semi structured interviews that have been thematically coded.

Phase 3 Materials

Focus Group Prompt Points

Figure 9.9 below is an image of the prompt points used for Focus Group. This was used in Phase 3 of Research (see Section 3.3).



Focus Group Questions

- Pick which best describes you
  - Haven't started
  - Had a look
  - Had a go
  - Bout half way
  - Im done
- Run through with prompts (group pre rob pitch)
  - Does this make sense
  - Do you understand what you need to do in this part?
- Can you explain the assignment to me? (group post rob pitch)
  - As a whole
  - Anyone jump in and help out when you want
- How do we feel about the idea of teaching?
  - What's good about it?
  - What's not?
  - Were specific interesting parts along the way?
- Based on the topics, who feels confident to teach this
  - Why do you feel/not feel confident?
  - What are some strats you'd use?
  - Is this good revision?
- How do you feel about having your work be taught in a class

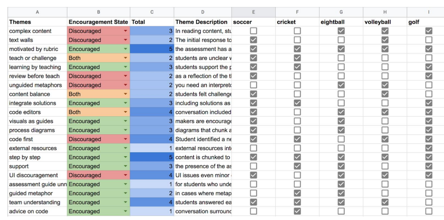
Figure 9.9: Prompt points used for the assessment workshops and focus groups.

Focus Group Audio Files

The audio files for the 5 focus group conducted in Phase 3 of research can be found in the */phase_3* folder of auxiliary materials. They are named according to the emoji designated to the group on slack (see Section 3.3.1)

Focus Group Thematic Notion Analysis Data

Figure 9.10 below is an image of a dataset. This dataset details thematic Notions discussed during focus groups. This was collected in Phase 3 of Research (see Section 3.3). A csv file of this dataset can be found in the /phase_3 folder of auxiliary materials and is titled "focus-group-thematic-notion-analysis.csv".



Themes	Encouragement State	Total	Theme Description	soccer	cricket	eightball	volleyball	golf
complex content	Discouraged	3	In reading content, stu	☐	☐	☑	☑	☑
text walls	Discouraged	2	The initial response to	☑	☐	☐	☑	☐
motivated by rubric	Encouraged	5	the assessment has a	☑	☑	☑	☑	☑
teach or challenge	Both	2	students are unclear v	☑	☑	☐	☐	☐
learning by teaching	Encouraged	3	students support the p	☑	☑	☐	☐	☑
review before teach	Discouraged	2	as a reflection of the t	☑	☐	☐	☐	☑
unguided metaphors	Discouraged	2	you need an interpret	☐	☐	☑	☑	☐
content balance	Both	2	students felt challenge	☑	☐	☐	☑	☐
integrate solutions	Encouraged	3	including solutions as	☑	☑	☐	☐	☑
code editors	Both	4	conversation included	☑	☐	☑	☑	☑
visuals as guides	Encouraged	3	makers are encourage	☑	☐	☑	☐	☑
process diagrams	Encouraged	3	diagrams that chunk a	☑	☐	☑	☐	☑
code first	Discouraged	4	Student identified a ne	☑	☑	☐	☑	☑
external resources	Encouraged	1	external resources int	☐	☐	☐	☐	☑
step by step	Encouraged	5	content is chunked to	☑	☑	☑	☑	☑
support	Encouraged	3	the presence of the as	☐	☑	☑	☐	☑
UI discouragement	Discouraged	4	UI issues even minor	☑	☐	☑	☑	☑
assessment guide unn	Encouraged	1	for students who unde	☐	☐	☑	☐	☐
guided metaphor	Encouraged	2	in cases where metap	☐	☑	☑	☐	☐
team understanding	Encouraged	4	students answered ea	☑	☑	☑	☑	☐
advice on code	Encouraged	1	conversation surrounc	☐	☑	☐	☐	☐

Figure 9.10: Thematic Notions discussed during focus groups of Phase 3 research.

Focus Group Thematic Notion Description Table

Table 9.2 below records the descriptions of Notions for Focus Groups analysing the meta-design prototype.

Notion	Description
complex content	In reading content, students expressed observation of dissonance between their perception of instructional strategy and how that applies to the task the strategy aim to guide student to effectively complete
text walls	The initial response to large amounts of text in a challenge as part of this eLearning platform leads to the discouragement state.
motivated by rubric	The assessment has aspects outside the explicit marked criteria. when students are confused about how to interpret the rubric they are discouraged. asking these questions and

	alleviating these confusion was a big part of the meta-design process. The most common instance of this was wondering how complex their puzzle is which was explained as it's better to have a great lesson with an okay challenge than a great challenge with an okay lesson.
teach or challenge	students are unclear what aspects of p5.js they need to explain and what they think of as assumed knowledge.
learning by teaching	students support the process of the assessment guide expressing their aggregate view that in explaining programming concepts they must create effective Syllogisms i.e. logical arguments in their own mind for how certain mechanics function before they can teach effectively. they believe that through teaching, they can personally arrive at an effective understanding of a programming concept which increases their efficacy in its use.
review before teach	as a reflection of the theme learning to teach. students felt discouraged to put forth their ideas without assurance of a review process to curate their lessons and ensure they did not espouse bad coding techniques to new students.
unguided metaphors	you need an interpreter to explain complex metaphors that explains what the metaphor means, otherwise keep content simple
content balance	students felt challenges that use a variety of design patterns well balanced to form a holistic perspective of a concept were more encouraging than challenges that were polluted with a certain design pattern
integrate solutions	including solutions as part of challenges was universally supported and mentioned independent of prompting questions. Some reasons given included the ability for advanced students to optimise their solution with the best solutions, helping people who missed a step catch and and the feeling of support knowing that the solution is there provided. it

	was also seen to shift the competition from being the first to submit a solution to being the first to understanding the code.
code editors	conversation included how to use code editors, what's the best way to put comments in code editors, and when makers but themselves in the position of learning, general student encouragement from using code editors in challenges
visuals as guides	makers are encouraged by visuals they can aspire to recreate or use as conceptual guides to guide learners. This was found from feedback on the code process flow and puzzle sketch.
process diagrams	diagrams that chunk a concept for a task into steps encourages students by helping them feel the task is manageable when chunked into steps.
code first	Student identified a need to explain how to make the code first then explain how to break down into steps then explain how to write instructions to introduce and contextualise steps. the lack of this was discouraging
external resources	external resources interesting for students who are curious about the connection between challenges and its relationship to the p5.js library
step by step	content is chunked to provide smaller wins, simple goals and easier cognitive load for students. students in focus groups predominantly considered this to be the way in which they conceptualised their own learning process and felt encouraged to see that manifested in a challenge structure
support	The presence of the assessment guide makes students feel supported, more confident and free from anxiety that impedes performance while maintaining the encouragement for motivation to learn. they feel it's exciting, interesting, unique and provides a safety net. students mentioned if they were provided with

	the student made challenges they were making they would feel supported in the knowledge that these were made by people only a semester ahead of them which gave them a concrete goal.
UI discouragement	UI issues even minor discourage students when it works, it's invisible and not mentioned in terms of good ui but in terms of other positive aspects like step by step, visual emphasis etc.
assessment guide unneeded	for students who understood what they needed to get started from the assessment brief, the assessment guide was unneeded.
guided metaphor	in cases where metaphors were understood they were extremely useful at improving understanding which brought about a self cultivation of motivation to learn
team understanding	students answered each other's questions, pointed out flaws and learnt from each during the focus groups. the collective became more engaged as the session continued. we believe this is due to an adoption of self assurance that it was okay for them to lead the conversation
advice on code	conversation surrounded debugging, understanding code snippets and fluidly moved from conceptual design aspects to practical aspects. this demonstrated the need for social facilitation to alleviate misunderstanding of content that manifested through a spontaneous question

Table 9.2: Description of Notions for Focus Groups on meta-design framework

Phase 5 Materials

Student Made Challenge Heuristic Data

Figure 9.12 below is an image of a dataset. This dataset details the data collected from expert heuristic evaluations of student made challenges. This was collected in Phase 5 of Research (see Section 3.5). A csv file of this dataset can be found in the /phase_5 folder of auxiliary materials and is titled "student-made-challenge-heuristic-data.csv".

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	
1	Timestamp	How would you r	This challenge e:	This challenge w	This challenge u:	This challenge h:	This challenge u:	This challenge u:	This challenge pr	This challenge h:	This challenge u:	This challenge u:	This challenge u:	This challenge u:	This challenge u:	This challenge u:	Exper
2	10/16/2020 18:36	5	2	3	3	4	1	5	4	1	5	5	1	2	4	1	
3	10/16/2020 18:52	5	1	4	5	3	1	2	5	1	5	5	1	1	5	1	
4	10/16/2020 19:04	5	1	5	3	5	1	4	5	1	5	5	1	1	3	1	
5	10/16/2020 19:28	5	1	5	4	5	1	3	5	1	5	5	1	1	5	1	
6	10/16/2020 19:40	3	2	3	4	3	1	4	1	2	5	4	1	2	5	1	
7	10/16/2020 19:54	5	1	5	3	5	1	5	5	1	4	5	1	2	5	1	
8	10/16/2020 19:57	5	1	5	4	5	1	5	5	1	5	4	2	2	5	1	
9	10/16/2020 20:05	5	3	5	4	5	1	4	3	1	5	4	2	1	4	1	
10	10/16/2020 20:49	4	1	5	5	5	2	4	2	2	4	3	2	2	5	1	
11	10/16/2020 20:55	2	5	3	3	3	4	3	2	3	4	4	4	2	5	1	
12	10/20/2020 10:25	4	1	5	4	5	2	3	4	2	5	3	1	3	4	2	
13	10/20/2020 10:36	4	2	4	2	4	2	3	4	2	2	5	2	4	4	3	
14	10/20/2020 10:42	4	1	3	4	5	1	1	5	3	5	1	1	3	1	1	

Figure 9.12: The data collected from expert heuristic evaluation of student made challenges

2019 and 2020 Creative Coding Assessment Data

Figure 9.13 below is an image of a dataset. This dataset details deidentified assessment 1 marks for 2019 and 2020 Web Design and Technologies cohorts. This was collected in Phase 5 of Research (see Section 3.5). A csv file of this dataset can be found in the /phase_5 folder of auxiliary materials and is titled “2019-and-2020-creative-coding-assessment-data.csv”.

	A	B
1	A1 Creative Coding Marks 2019	A1 Creative Coding Marks 2020
2	Percentage	A1: Creative Coding Challenge (232573) x/20
3	0	0.00
4		0.00
5	40	0.00
6	40	0.00
7	40	0.00
8	43.33	0.00
9	46.67	0.00
10	46.67	0.00
11	53.33	0.00
12	53.33	0.00
13	53.33	5.00
14	53.33	9.00
15	53.33	9.00
16	53.33	10.00
17	56.67	10.00
18	56.67	10.00
19	56.67	10.60
20	56.67	11.00
21	60	11.00
22	60	11.00
23	60	11.00
24	60	11.00
25	60	11.00
26	60	11.00
27	60	11.00
28	60	11.00
29	60	11.50
30	60	11.50
31	60	11.50
32	63.33	11.90
33	63.33	12.00
34	63.33	12.00
35	66.67	12.00

Figure 9.13: Deidentified Assessment 1 Marks for 2019 and 2020 Web Design and Technologies Cohorts.

Stage 1 Materials

Expert Interview Transcripts

Figure 9.14 below is an excerpt from an expert interview transcript. This and other transcripts were collected in Stage 1 of the Design Process (see Section 4.1). These have been stored as txt files and can be found in the in the /stage_1/round-three folder of auxiliary materials.

```
It's been I think for the students so far it's been good hmm week one. I think there's a bit of a like where do I go
and they want that kind of handhold yes yeah but I think that like after they sort of done the challenges for a week
things started to make a bit more sense for sure.

And I think naturally as a student I'm expecting it to branch out a bit more but at the moment I need that kind of
handholdy, what do I do next yeah because all the time you just tell them to like go and learn stuff they don't know
what to to learn and they can't learn yeah do you think that has anything to do with the fact this is very new for them
in terms of like this way of teaching yeah, although I I'm finding that over the last couple of years the students are
becoming more comfortable with learning online.
```

Figure 9.14: An excerpt from an expert interview transcript.

Stage 2 Materials

Student Made Challenge Review Data

Figure 9.15 below is an image of a dataset. This dataset contains feedback on OLTs from the research team. This dataset was used in Stage 2 of the Design Process (see Sections 4.2). A csv file of this data can be found in the */stage_2* folder of auxiliary materials and is titled “student-made-challenge-review-data.csv”.

Topic	Type	Good candidate?	Positive	Negative	Potential Tags
Loops	Introductory	☐		This is a good tutorial, but needs to be	
Transformations	Exploratory	☐	Exercises too complex		
functions	Introductory	☑	great recursion syntax		characters, complex
random function	Introductory	☑	parameters up the top is nice for function based tutorials		
Perlin	Introductory	☑	nice illustration of the difference between perlin noise		walker
map function		☐	problem focused explanation of map function	not much setup with the example. need to	mouseX, mouseY
conditionals		☐		too complex and broad. needs to be more	
For loops		☐		not adding anything new..	
Noise	Introductory	☑	"how code takes a different path" great opening	doesnt explain boolean concept	Writing Style, concept
Key functions	Introductory	☑	fun exercise to play with	the image for first task seems interactive	game
Mouse Functions	Introductory	☑	Great introduction, great use of exercises and they		
Conditionals	Introductory	☑	A great, well thought out tutorial that incorporates		
3D Heightmap	Exploratory	☑	Best for advanced students. A detailed and well		
Loops & Conditionals	Introductory	☑	The content is quite dense and covers a lot but in a clear		
Functions	Introductory	☐	Good introduction for people who are very beginners	but not engaging enough	
Functions	Introductory	☐		Too basic, needs more substance	
Loops	Introductory	☐		Exercises were distracting and lost focus	
For Loops	Introductory	☑	Simple Structure, explains what for loops are for, why to	wriiting was a bit sloppy but can be built	Simple
Variables	Introductory	☑	The writing style is quite engaging. I like the		Writing Style
For Loops	Introductory	☑	having the examples of for loop and copy paste alt. right	the exercises are random and don't really	comparison
Functions	Introductory	☑	cool annotated picture of a function		infovis
OOP & Animation	Exploratory	☑	Really detailed, and has a mixture of simple and		
Colour	Introductory	☑	At times confusing and hard to follow		
Easing	Exploratory	☑	Very specific tutorial with great interactive		
For Loops	Introductory	☑	Less Exercises than the first but I like the walk through	Wasn’t engaged in the writing style	Rhetorical Q
For loops	Introductory	☑	like the "loops inside loops" line		
Map() Function	Introductory	☑	Content is highly interactive and engaging,		

Figure 9.15: Feedback on OLTs from the research team.

Stage 3 Materials

Conceptual Design Slidedeck

Figure 9.16 below is the title page from a slidedeck of conceptual design. This dataset contains feedback on OLTs from the research team. This dataset was used in Stage 3 of the Design Process (see Sections 4.3). A pdf file of this slidedeck can be found in the /stage_3 folder of auxiliary materials.

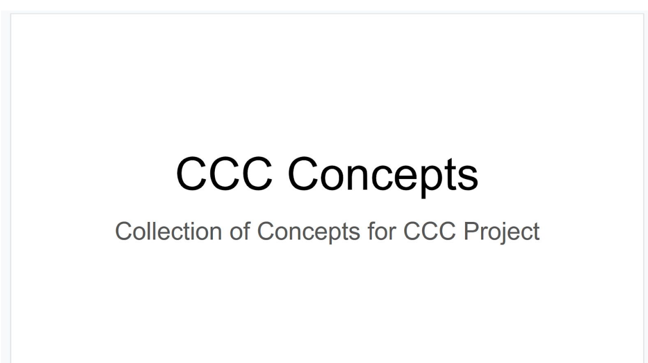


Figure 9.16: The title page from a slidedeck of Conceptual Design.

Stage 4 Materials

eLearning Prototype Figma export

Figure 9.17 below are mockups of the eLearning platform in a figma workspace. This dataset contains feedback on OLTs from the research team. These mockups were created Stage 4 of the Design Process (see Sections 4.4). Pngs of these mockups can be found in the */stage_4/elearning_prototype_figma_export* folder of auxiliary materials.

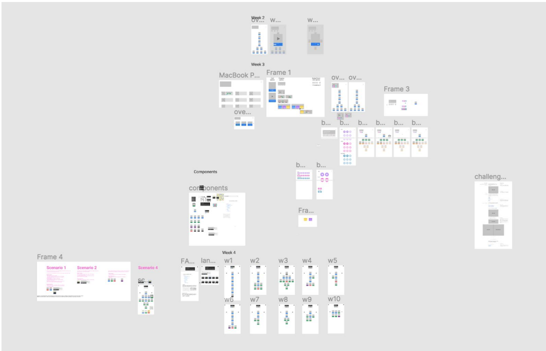


Figure 9.17: Mockups of the eLearning platform in a Figma workspace.

Developed Prototype

Figure 9.18 below is an image of the deployed development of the eLearning platform prototype. This prototype was developed in Stage 4 of the Design Process (see Sections 4.4). You can find the deployed prototype at https://designprogramming.io/

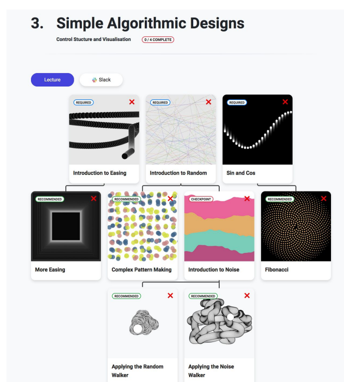


Figure 9.18: Development of the eLearning platform prototype.

Stage 5 Materials

Assessment Guide Prototype Figma export

Figure 9.19 below is an image of mockups of the assessment guide for meta-design of student-made challenges in a Figma workspace. These mockups were created in Stage 5 of the Design Process (see Sections 4.5). Pngs of these mockups can be found in the */stage_5/assessment_guide_prototype_figma_export* folder of auxiliary materials.

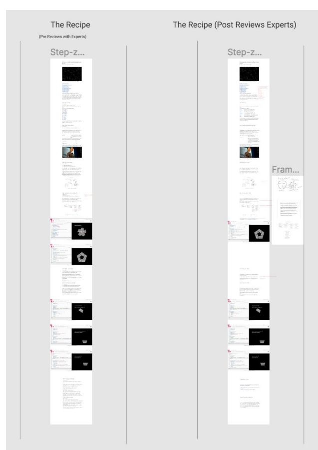


Figure 9.19: Mockups of the assessment guide for meta-design of student-made challenges in a Figma workspace.

Developed Assessment Guide

Figure 9.20 below is an image of the deployed development of the assessment guide for meta-design of student-made challenges prototype. This prototype was developed in Stage 5 of the Design Process (see Sections 4.5). Website files of this prototype can be found in the */stage_5/developed_assessment_guide* folder of auxiliary materials.You can also find the developed assessment guide at https://halcha.github.io/challenge-recipe/

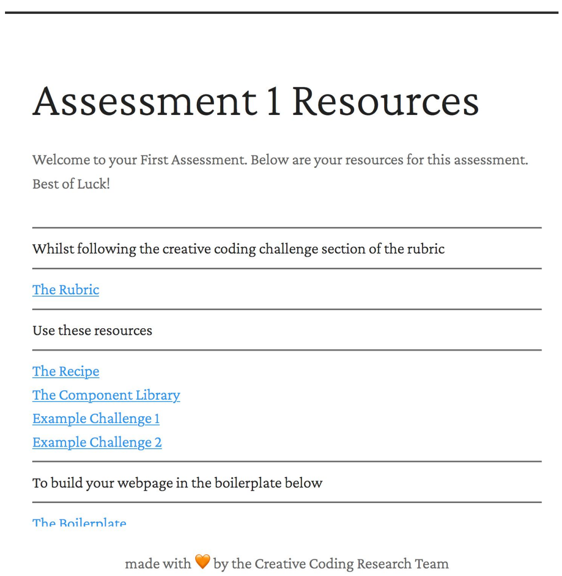


Figure 9.20: Development of the assessment guide for meta-design of students made challenges in a Figma workspace.