Exploring teachers' needs-supportive practices and self-efficacy to engage students in the online learning environment during the COVID-19 pandemic:
A case study of two science teachers in an Australian university pathway provider

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Abstract

Australian university pathway programmes annually prepare many domestic and international students for higher education (HE) study. Highlighted by government reports and surveys, the pandemic exposed pathway students' dissatisfaction with online learning. The high demand for pathways, the concerning disengagement found in online learning and the lack of research on pathway programmes highlight the need to investigate student engagement.

The present case study employed qualitative research methodology to understand the strategies implemented by and self-efficacy development in two 'expert' science teachers in an Australian pathway provider. Both teacher participants were new to online teaching at the time when COVID began. Guided by self-determination theory (SDT; Deci & Ryan, 2010), the study explored teachers' use of needs-supportive strategies for online challenges: concentration, collaboration and independent learning. Using Bandura's (1976) self-efficacy framework, the study also examined how science pathway teachers new to online teaching developed self-efficacy during the sudden shift from face-to-face to online teaching. Data were collected longitudinally over one semester through interviews, lesson observations and artefacts, then analysed thematically.

The findings reveal five needs-supportive strategies pertaining to collaborative learning and four addressing sustaining concentration and independent learning. Notably, many strategies are competence- and autonomy-supportive, with minimal focus on building relatedness. The findings also confirmed that most strategies were adapted and modified from practice in the pre-Emergency Remote Teaching (ERT) era, supporting the notion of 'resilient' pedagogy, which is adaptive, flexible and agile and would not crumble in the face of a change in modality when confronted by disruptions.

The findings also identified the factors that could enhance teacher self-efficacy within mastery experience, vicarious experience and verbal persuasion. Importantly, the finding highlight that emotional states have a more immediate and direct effect on how teachers perceive each source (mastery experience, vicarious experience and verbal persuasion) whiledeveloping self-efficacy in online teaching. Overall, the study's findings have empirical, theoretical and practical implications for online teaching.

Keywords: Online learning, Teachers' needs-supportive practices, Self-efficacy, COVID-19 pandemic, Science education

Impact Statement

This study offers timely insights, amid the COVID-19 pandemic, into two critical issues: the development of teachers' self-efficacy in online teaching and the strategies they employ to foster student engagement in the online environment. The implications span the areas of theory, pedagogy, professional development and the research community.

Effect on Theories

This study applied Self-Determination Theory (SDT) to explore the strategies used by science teachers in Australian pathway programmes during the sudden shift to online teaching, known as Emergency Remote Teaching (ERT). It is one of the few studies that explores online learning during ERT in a pathway-provider context using SDT and understands pathway teachers' self-efficacy development.

The findings confirm that SDT is a sound explanatory framework that can explain the rationale behind teacher pedagogical choice and learning design to satisfy learners' psychological needs in competence, relatedness and autonomy. In addition, the study provides fresh insights into teacher self-efficacy in the realm of online teaching. It challenges the conventional notion of emotional states as a separate source of self-efficacy, distinct from other elements like mastery experience, vicarious experience and verbal persuasion. The findings highlight an intriguing argument: emotional states have a more immediate and direct influence on how teachers perceive these other three sources when developing their self- efficacy in online teaching.

Effect on Pedagogy

This study opens new avenues for discourse on pedagogies within the realms of online learning, student engagement and university pathway programmes. In a period where educators and institutions were grappling with the challenges of ERT amidst the pandemic, the study's insights emerge as a useful set of tools for refining pedagogical practices and enriching student experiences.

The insights also catalyses dialogues aimed at bridging the realms of face-to-face and online education, paving the way for innovative online learning approaches that hold promise for the educational landscape of the future.

Effect on Professional Development

This research contributes to the growing body of knowledge of teacher professional development by exploring teachers' self-efficacy and needs-supportive strategies. In an era when educational institutions are integrating technology and online elements into their curricula, investing in the professional growth of teachers becomes imperative. This investment ensures the delivery of a high-quality and captivating online learning experience, both during and after ERT. The study's findings can guide the creation of targeted training programmes and resources to equip teachers with the needs-supportive strategies and self- efficacy the need to excel in online teaching, creating a positive ripple effect on student engagement and success.

Effect on the Research Community

The dissemination of research findings remains a cornerstone of knowledge advancement. The findings of the pilot study were shared at the IOE Doctoral Conference in June 2020. The main study's findings were presented during a staff development session at my workplace (University of Technology Sydney College) in November 2022. Future plans include a conference presentation at the International Self-Determination Theory Conference and the International Conference on Performing and Self-Efficacy, as well as disseminating the findings through journal articles.

Contents

Declaration

I, Kit Yan Chu, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

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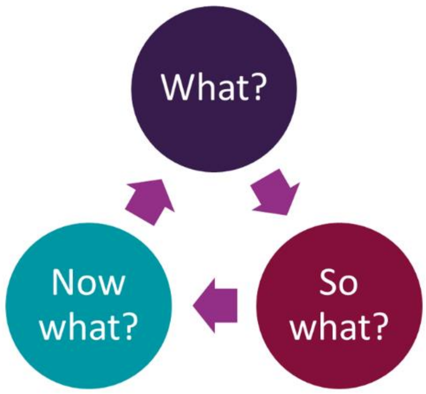
Reflective Statement

In preparation for writing this reflective statement, I revisited the work completed earlier in my EdD journey, which includes the Foundations of Professionalism (FoP), Methods of Enquiry 1 (MoE1) and Methods of Enquiry 2 (MoE2) modules and my Institution-Focused Study (IFS). I adopted Rolfe et al.'s (2001) 'What? So what? Now what?' framework to structure my reflections. The 'What?' and 'So what?' components allowed me to describe my experiences and evaluate the significance of the experiences from my perspective. The 'Now what?' accounts for my next step: i.e., how my experiences and reflections have influenced my subsequent exploration in my EdD research journey.

Figure 1

The 'What? So what? Now what?' framework



Note. Adapted from *Critical reflection in nursing and the helping professions: A user's guide*., by G. Rolfe, D. Freshwater, & M. Jasper, 2001, Palgrave Macmillan.

Foundations of Professionalism (FoP)

What and So What?

During the FoP module, I explored the challenges confronting teachers in the complex Higher Education (HE) landscape, particularly within the curriculum, pedagogy and assessment triad. On one hand, certain difficulties can be perceived as opportunities for professional growth and advancement. Through the use of our accumulated knowledge and experiential insights, we diligently and actively strive to enhance our pedagogical approach, thereby fostering improved educational outcomes for our students. It is important, however, to note that there are certain challenges that are beyond our influence. These challenges include heightened accountability, diminished autonomy and trust and the presence of micro-politics, wherein individual professionals have limited capacity to alleviate the prevailing circumstances. To address these challenges, it is imperative to cultivate a well-developed and innovative professional imagination as a guide for improvement. In the absence of a vivid imagination, individuals tend to respond defensively to these challenges, resulting in a series of crises without much prospect of finding solutions or gaining insights. The cultivation of professional skills necessitates the implementation of effective professional-development programmes that prioritise the integration of curriculum, pedagogy and assessment, while also considering the individual's personal growth. Teachers serve as catalysts for change, actively facilitating our personal growth and development rather than imposing fixed notions upon us. In this regard, individuals have the potential to cultivate their expertise as educators, enabling them to adeptly navigate evolving circumstances while effectively imparting knowledge within their respective disciplines.

What's Next?

The FoP module laid the groundwork for my subsequent exploration in MoE1, where I explored student engagement in biology. My shift from a defensive stance to a proactive and imaginative approach to challenges influenced my approach to formulating the MoE1 proposal. I began to see the challenge of student engagement as an opportunity rather than an obstacle or a deficit. This transformative experience has prepared me to navigate the complexities of student engagement and its effect on academic performance in a positive and hopeful way.

Methods of Enquiry 1 (MoE1)

What and So What?

In the MoE1 module, I developed a proposal to explore first-year university students' engagement in biology. Recognising the significance of student engagement in STEM education, particularly in biology, I aimed to investigate its effect on attrition, academic performance and future participation in STEM careers. The limited existing research in this area highlighted the need for this exploratory study. The proposed theoretical framework aimed to establish a link among engagement, motivational beliefs and achievement. The findings from this research could reveal effective instructional practices and promote student engagement and academic performance in first-year university biology courses.

Through the proposal writing for MoE1, I learned the importance of showing that there is a problem and that this project can help solve it. I also developed my skills at explaining what my research goals are, how I plan to reach them, how I measure them and the potential implications the research might have.

What's Next?

The experience of developing this proposal fuelled my determination to contribute to the advancement of STEM education, particularly in the context of biology. First, the experience of formulating this proposal heightened my awareness of the significance of conducting research that can lead to meaningful and practical applications in the field of education. Second, recognising the importance of addressing student engagement and its effect on academic achievement, I felt compelled to pursue this research in MoE2, focusing on teacher beliefs about student engagement.

Methods of Enquiry 2 (MoE2)

What and So What?

In the MoE2 module, I conducted research on teacher perceptions of student engagement in biology. The study explored how teacher views on engagement influence student learning and achievements. The study involved interviews with three biology teachers at a tertiary institute in Sydney, Australia. It employed thematic analysis to categorise their perceptions into different types and levels of engagement. The findings revealed valuable insights into the multifaceted nature of student engagement in science. More specifically, teachers acknowledged behavioural and cognitive indicators more frequently than emotional ones while recognising the significance of social interactions in science learning. Interestingly, a new dimension of goal-oriented engagement emerged during the study, further enriching our understanding of teacher perceptions of student engagement in the tertiary environment. The study holds implications for guiding teachers' practices in fostering engagement among students with diverse backgrounds.

What's Next?

The experience and insights from MoE2 have significantly influenced my subsequent exploration in my Institution-Focused Study (IFS). The finding of social engagement in MoE2 has laid the groundwork to explore relatedness, teacher practices and student engagement in the context of first-year university biology courses. Building on this qualitative approach, I planned to use a larger number of participants to gain a comprehensive perspective on the dynamics of student engagement in biology education.

Institution-Focused Study (IFS)

What and So What?

Conducting the IFS was a pivotal experience in my EdD journey, allowing me to explore student engagement in first-year biology courses. Grounded in Self-Determination Theory (SDT), the study aimed to uncover the effect of relatedness and effective teacher practices on student engagement. The findings revealed insights into the multifaceted nature of student engagement and the crucial role of teacher practices in fostering relatedness. These findings have practical implications for improving teaching strategies and enhancing engagement in HE settings.

Throughout the qualitative design approach, I conducted focus group interviews with 16 first-year domestic and international university students, both high and low achievers, at a tertiary university pathway provider in Sydney, Australia. The findings from the study provided significant insights into the multifaceted nature of student engagement in science. Notably, the study highlighted that relatedness extends beyond the teacher–student connection and includes the students' connection with the subject matter, emphasising the importance of fostering positive and lasting connections with the subject material. Moreover, the identification of seven major categories of teacher practices revealed their crucial role in supporting relatedness between both students and teachers and between students and the subject matter. This, in turn, significantly affected student engagement, particularly in its emotional and cognitive aspects.

The study's exploration of student perceptions based on different characteristics, such as international vs domestic students and varying achievement levels, further enriched my understanding of promoting student engagement. These findings hold significant implications for guiding teachers' practices in promoting relatedness and enhancing engagement among students with diverse backgrounds and characteristics. The insights gained from this study contribute to our understanding relating to more targeted and effective teaching strategies in HE settings.

What's Next?

My experience and reflections during the IFS profoundly affected the direction of my research as I moved into the thesis stage of my EdD. The use of SDT has inspired me to further explore the two previously unexplored roles of competence and autonomy in my research, in addition to relatedness in student engagement. Building upon the qualitative approach used in the IFS, I planned to employ more data-collection time points as well as tools, including interviews, lesson observations and artefacts, in my thesis stage to better understand the complex dynamics among SDT, teacher practices and student engagement. Data triangulation supports the trustworthiness of my research findings. Moreover, during my MoE2 assignment preparation, I read that, while many factors could influence student engagement, the impact of teachers' beliefs and practices appear to be more critical than other factors, such as students' self-motivation and family support (Prebble et al., 2004). Thus, I believe that understanding teachers' perspectives could be equally powerful at providing a deep understanding of student engagement and SDT in HE in the unique HE context of the Australian university pathway programme.

Thesis

What and So What?

Throughout my thesis, I examined a critical topic on exploring teachers' needs-supportive practices and their self-efficacy in engaging students. Initially, my research aimed to investigate how UTS College science teachers could actively involve pathway students during face-to-face tutorials, with the goal of reducing dropout rates. However, the sudden shift to online learning due to the COVID-19 pandemic disrupted this original plan.

The context of the pandemic raised concerns about low student engagement in online learning, especially within science programs at Australian university pathway providers. Understanding and tackling these challenges became crucial in ensuring a meaningful learning experience for students during Emergency Remote Teaching (ERT). Grounded in Self-Determination Theory (SDT) and self-efficacy theory, my qualitative study was designed to shed light on teacher practices and self-efficacy in online teaching, aiming to enhance student engagement in this virtual environment.

Through this research, I gained valuable insights into the strategies employed by teachers to support student engagement in the online learning environment. It was particularly enlightening to witness the resilience of needs-supportive practices as teachers adapted these strategies from face-to-face teaching to the virtual setting. Additionally, I explored how teachers developed their self-efficacy for online teaching through various sources, particularly the important roles played by mastery experiences and emotional states during the abrupt shift to remote teaching. This study highlighted that self-efficacy beliefs, once seen as difficult to change, are indeed malleable and that teachers can actively foster their self-efficacy to enhance their online teaching practices. By understanding the practices and sources that influence teacher self-efficacy, policymakers, educators and institutions can better support educators in navigating the challenges of online teaching and fostering student engagement.

What's Next?

I frequently pondered how to effectively engage in my EdD journey towards completing the thesis. The thesis stage has proven to be an invaluable learning experience. Beyond academic writing, I have acquired significant insights into effective online teaching design and practices by exploring how science teaching can promote student engagement. Although the research process can be frustrating, with the guidance of my supervisors, Richard Freeman and Emma Newall, my experience evolved into an enriching and exhilarating journey. This research study has allowed me to reflect on my professional values and potential improvements to my future practices. Another unexpected benefit was the opportunity to share findings with science teachers at the research site (my workplace) that could positively affect student engagement in their classrooms.

The current study attempted to capture a snapshot of how university pathway science teachers used strategies to solve problems and engage students in the online environment during ERT. The strategies or sources of self-efficacy explored in this study do not constitute explicit procedures or prescriptions for achieving successful online teaching. Rather, I believe that these strategies reflect the teachers' professionalism and passion, the linchpin of effective teaching, serving as the driving force for designing such remarkable online learner-centric experiences. Teachers can consider factors like students' academic proficiency, language levels and cultural contexts, adapting research insights to their specific classroom dynamics. A teacher can enhance their self-efficacy and adeptly apply research- and theory-driven strategies tailored to the unique needs of their student cohorts.

Knowing that my work has the potential to contribute meaningfully to the field of education and student engagement, I am excited to disseminate the findings of my thesis through publications and conference presentations. Sharing this knowledge with the broader educational community can foster positive change and innovation in online teaching practices. I am also motivated to continue my research by conducting institution-focused research to explore the implementation and effect of needs-supportive practices in different contexts, such as other science subjects or university pathway providers. Through these endeavours, I aim to deepen my understanding and drive advancements supporting student engagement and study success in university pathway programmes.

Chapter 1: Overview of Study

This chapter begins with my educational and professional background and the background of the research site, University of Technology Sydney (UTS) College as a pathway programme provider. I also discuss why I focused my study on science pathway students, primarily because of their worsening attrition rates. The chapter then discusses the significance of the research topic for pathway students and how the abrupt shift to online learning further challenges their learning. The chapter concludes with the thesis structure.

Researcher's background

My Educational Experiences

My journey began with a Bachelor of Science in biology, followed by a Master of Philosophy in science, a Master of Education in educational psychology and a Postgraduate Diploma in education, majoring in biology. These qualifications laid the foundation for my teaching career, which began in Hong Kong, where I taught science and biology to students from years 7 to 12. Subsequently, I transitioned to HE and taught first-year science subjects at Western Sydney University in Sydney, Australia. In 2015, I joined UTS College, where I have been working since.

Background and My Work at the Research Site

UTS College, operated by the University of Technology Sydney (UTS), is a university pathway programme provider. Pathway programmes aim to facilitate the transition of students from diverse educational backgrounds into universities (Adams et al., 2009; Velliaris, 2019). UTS College offers three major programmes: diplomas, foundation studies and an English-language programme. These programmes cater to domestic and international students who do not meet the academic or English entry requirements for an HE programme but wish to study at HE level (Agosti & Bernat, 2018; Percival et al., 2016). By successfully completing these programmes, students are eligible for undergraduate and graduate degrees in HE. Hence, pathway programmes offer an alternative route for prospective HE students.

During my time at UTS College, I taught biology subjects in the diploma programme, which were also taught by the teacher participants in this study. Such teaching experience provided me with a comprehensive understanding of the curriculum, pedagogy and assessment for these subjects. Through interactions with students, I witnessed their excitement and anxiety at the beginning of each semester. I also became aware of the challenges they faced due to their limited academic preparation and knowledge. This sparked my interest in exploring the experiences of pathway students who enter HE unprepared and are confronted with its expectations in their first year. I believe that fostering early positive engagement in the pathway programme and their studies can mitigate disengagement and dropout rates in the later undergraduate (and graduate) years.

Interest in Pathway Students

My interest in pathway students extended beyond my teaching duties at UTS College. I actively contributed to the Student Engagement Project by re-designing a range of orientation activities based on the five senses of success (Lizzio, 2016) to prepare students for their tertiary education. I organised and facilitated Study Success workshops and Science Bootcamps, providing valuable support for the seamless transition of Diploma of Science students into Higher Education. This interest also influenced my research topics during my Doctor of Education (EdD) journey at the UCL Institute of Education (IOE), where I focused on investigating student engagement among pathway students and teachers in Methods of Enquiry 1 and 2 and Institute-Focused Study.

Attrition in Science Students at UTS College

In 2018, I became the Programme Manager, and my duties transitioned from teaching to overseeing educational projects, pathway products and strategic initiatives. This shift in responsibilities enabled me to examine student performance data and uncover a concerning issue: high attrition rates among pathway students, particularly those enrolled in the Diploma of Science programme. Attrition, characterised by early student withdrawal from a programme, is a common measure used to understand student discontinuation. According to a report by the Tertiary

Education Quality and Standards Agency (TEQSA) in 2017, pathway providers had an average student attrition rate of 27%, higher than the undergraduate average (20%) at universities. Over the past five years, each year's average attrition rate across UTS College pathway programmes ranged from 25.6% to 31.3%. Most alarmingly, the five-year average attrition rate in the Diploma of Science programme reached 41.8%.

Addressing student attrition in the Diploma of Science has become a priority at the College. Australia's Chief Scientist has highlighted the nation's need for STEM skills in its future workforce, emphasising that the country will face shortages in this area (Office of the Chief Scientist, 2020). The Australian Industry Group (AIG) also recognises the importance of STEM skills, stating that 75% of the fastest-growing occupations require such skills (AIG, 2013). Therefore, student attrition from HE science programmes can impede the growth and development of society generally. Furthermore, attrition negatively affects students by potentially harming their emotional well-being, limiting their social mobility and creating barriers to knowledge-based careers (Kuh, 2007; O'Brien, 2020; Schleicher, 2020; Tinto, 2012).

Original Study Goals

Based on my experiences and the above observations, my research initially aimed to examine how science teachers at UTS College support pathway students' engagement in face-to-face tutorials, with the intention of reducing attrition rates, but the COVID-19 pandemic disrupted this research context, as education transitioned abruptly to online learning.

Online Learning: Background, Student Dissatisfaction and the Need for Further Research

Due to the COVID-19 pandemic in 2020, all Australian HE institutions, including UTS College, experienced unprecedented changes in teaching and learning. The pandemic's arrival in Australia coincided with the start of the semester at many Australian HE institutions. All institutions have undergone ERT, which is defined as 'a temporary shift of instructional delivery to an alternate delivery mode due to crisis circumstances' (Hodges & Fowler, 2020). Most institutions, including UTS (2020) and UTS College (2020), delivered their courses online between March 2020 and June 2023.

The onset of the COVID-19 pandemic in 2020 necessitated significant changes in teaching and learning at Australian HE institutions for ERT. UTS College, like many other institutions, adopted online asynchronous and synchronous approaches. Synchronous tutorials took place through platforms like Zoom, enabling real-time interaction between teachers and students (Vivolo, 2019). Asynchronous learning occurred through pre-recorded lectures, interactive quizzes, readings and discussion forums, allowing for independent learning at each student's convenience (Coogle & Floyd, 2015).

While online teaching is not new, the sudden shift from face-to-face to online learning introduced challenges, particularly for those teachers and students with limited prior experience in online education (Saadati, 2021). Dissatisfaction with online learning was evident among students, including those in pathway programmes. Reports from the Tertiary Education Quality and Standards Agency (TEQSA) and subsequent surveys, such as the Student Experience Survey (SES, 2021) and the Quality Indicators for Learning and Teaching (QILT, 2021), indicated a sharp decline in student satisfaction ratings with online educational experiences. Although some may anticipate a return to face-to-face teaching after the pandemic could eradicate such disappointment, there are reasons to believe that online learning approaches will persist due to factors like travel restrictions, personal preferences and the development of remote work skills (Cengage, 2022; Peimani & Kamalipour, 2021).

Study Focus 1: Strategies Implemented by Teachers

According to Self-determination Theory (SDT), all humans have three basic psychological needs: competence, autonomy and relatedness, the satisfaction of all of which is essential for effective functioning and wellness. This study adopts SDT as a lens through which to understand how teachers use different strategies to help students tackle the online learning challenges by meeting their innate psychological needs.

Study Focus 2: The Development of Teacher Self-Efficacy Beliefs

Bandura (1977) defines *self-efficacy* as an individual's belief in his or her ability to carry out the behaviours required to achieve specific performance goals. Considering that many teachers did not have experience of online teaching (Johnson et al., 2020; Ma et al., 2021), it is crucial to explore the factors that facilitate the development of teachers' self-efficacy during the abrupt shift from face-to-face to online teaching. The lack of experience in online teaching strongly suggests that mastery experience (e.g., prior online teaching experience), vicarious experience (e.g., observing peers or mentoring), social persuasion (e.g., feedback from others) and emotional arousal (e.g., positive emotions) may be lacking when teachers were forced to shift their teaching to online abruptly (Hemmings, 2015; Matos et al., 2022; Leonardo, Murgo, & Sena, 2019). Ma et al.'s (2021) study found that teacher self-efficacy for online instruction did not significantly increase in one semester during the COVID-19 school lockdown in China. Ma et al.'s findings are consistent with Ertmer's (1999) assumption that teacher self-efficacy could be an intrinsic barrier that is deep-seated, enduring, intangible and difficult to shift. Additional research is needed to determine whether teachers' self-efficacy for online teaching changed (or did not) during ERT in other contexts, such as university pathway programmes in Australia. It is also critical to understand how various factors contribute (or do not contribute) to such changes within a short period because these influence teachers' confidence, capability and efforts to implement strategies to support student engagement in online learning.

Significance of the Research

University pathway programmes play a crucial role in increasing Australian HE student enrolment. Pathway students, although underprepared for HE, have goals and aspirations (O'Brien, 2020). Supporting these students in their academic journeys is essential, as disengagement and attrition have negative consequences for the students themselves, the HE institution and society at large. Currently, limited research exists on university pathway programmes and the experiences of pathway students, making it crucial to explore effective support strategies. This research will benefit university pathway teachers, pathway providers and other institutions by providing insights into promoting student engagement during their first year in HE, particularly in the online learning context. The findings will contribute to the understanding of pathway programmes and their effect on student success. While this study will be of particular interest to the pathway provider and campus where I work, it may also be of interest to other pathway providers, both nationally and internationally, particularly those with similar student populations, as well as teaching online more generally.

Thesis Structure

To provide a clear overview of the thesis structure, the following chapters will address specific aspects of the research conducted.

Chapter 2: Review of Relevant Literature

This chapter presents a comprehensive review of relevant literature, addressing research gaps and justifying the study's purpose. It discusses the background and characteristics of Australian university pathway programmes, examines student attrition and engagement issues in the pathway context and explores the challenges faced by students during online learning. Additionally, it introduces the theoretical frameworks of SDT and self-efficacy beliefs, which guide this study. The research questions developed accordingly were:

1. How did science pathway teachers support student engagement and success in online learning during ERT, specifically addressing challenges in concentration, collaboration and independent study?
2. What factors contributed to science pathway teachers' self-efficacy for online teaching during ERT?

Chapter 3: Methodology

This chapter justifies the use of the interpretive epistemological stance and qualitative research methodology in this case study. It outlines the data-collection methods, including interviews, lesson observations and analysis of artifacts, implemented during the ERT period. Thematic analysis, as proposed by Braun and Clarke (2006), was used to analyse the collected data. Trustworthiness and ethical considerations are also discussed.

Chapter 4: Results

This chapter presents the findings of the study, drawing upon the theoretical framework of SDT (Deci & Ryan, 2010). It discusses the needs-supportive strategies employed by science teachers to address the challenges faced by students during online learning. Furthermore, it explores the factors contributing to the development of teacher self-efficacy in online teaching, guided by Bandura's Source of Self-Efficacy framework (1976).

Chapter 5: Discussion

The fifth chapter provides an in-depth discussion of the study's findings and their implications. It summarises and analyses the results, offering empirical, theoretical and practical implications. Additionally, it acknowledges the study's limitations and provides recommendations for future research studies.

Chapter 2: Literature Review

Expanding on the study overview presented in Chapter 1, this chapter reviews the relevant literature, identifies research gaps and justifies the purpose of this study. The chapter begins with a discussion of the background of Australian university pathway programmes and the characteristics of pathway students, followed by a discussion of the significance of student attrition and student engagement in pathway programmes. The chapter then discusses the difficulties that students in Australia face when learning online during ERT. The use of theoretical frameworks to explore the issues is then introduced and discussed. Finally, a summary of the research gaps and the context of the current study is presented.

Background of Australian University Pathway Programmes

The section is divided into four subsections, the first of which describes what university pathway providers and programmes are, followed by a discussion of the emergence of pathway programmes for international and domestic students. The characteristics of pathway students are described based on the background of these programmes, emphasising their vulnerability to attrition.

University Pathway Providers and Programmes

Over 2,200 university pathway programmes are available to prospective students worldwide. Common pathway programmes include English-language programmes, foundation studies and diplomas (Velliaris, 2019). Over 90% of these programmes were provided by English-speaking countries, with roughly 70% delivered in the United Kingdom, 16% in Oceania and 12% in North America (Wächter & Maiworm, 2014). These programmes aim to give prospective domestic and international students an alternative path if they do not meet the academic and/or English-language entry requirements for HE (Agosti & Bernat, 2018; Percival et al., 2016). The programmes equip students with the academic and language skills required for HE. Students who successfully complete these programmes are deemed to have met the entry requirements for the undergraduate degree.

Pathway programmes are known by various names in the research literature and publications. *Bridging programmes* (Ellis et al., 2001), *enabling programmes* (Andrewartha & Harvey, 2014), *foundation programmes* (Klinger & Murray, 2011), *sub-bachelor programmes* (Pitman et al., 2016), or *tertiary preparatory programmes* are some terms used to describe them (Morison & Cowley, 2017). According to Agosti and Bernat (2018), the name *university pathway programmes* is the most appropriate one and thus adopted in this study because 'university pathway' explicitly links students' ultimate destination and 'programmes' can refer to a spectrum of academic programmes offered by providers: i.e., foundation studies, diploma and English programmes.

Of the 189 registered HE providers in Australia, 146 offer pathway programmes that connect students to one of the country's 43 universities (Hodge et al., 2022). In Australia, university pathway providers can be either public or private. Most public providers are universities, such as the University of New South Wales. Private providers, such as Navitas, have commercial agreements with several universities (World Education News and Reviews, 2013). Other providers, such as UTS College—the study's research site—are private entities controlled by a university, the University of Technology Sydney (UTS). With this arrangement, UTS College provides pathway programmes that specifically bridge students to UTS (Adams et al., 2009). Therefore, students who complete the diploma programme at UTS College receive recognition of their prior learning equivalent to one full-time year's worth of credit points at UTS.

Pathway providers can offer programmes both onshore in Australia and offshore in other countries. In terms of student numbers, onshore programmes are generally more popular than offshore programmes (Velliaris, 2019). The offshore model was developed in response to overseas parents who preferred for their children to complete pathway programmes in their home countries before enrolling in Australian universities (McBurnie & Pollock, 2000). Offshore programmes, according to providers, can attract students early in their international study journeys. The current research took place on the onshore Sydney campus.

Pathway Programmes for International Students

The underlying cause of the increase in international students in pathway programmes is the Australian government's policy shift from aid to trade (Smart & Ang, 1993). Prior to 1984, international students could only be admitted to Australian HE if they were awarded a scholarship (Agosti & Bernat, 2018). The Colombo Plan, launched in 1951, was a post-World War II intergovernmental initiative to strengthen relationships and social and economic development between Australia and the Asia-Pacific regions (Back et al., 1996). The Plan prioritised education, and the Australian government sponsored talented students from member countries to study at Australian HE institutions. Over the last three decades, the Plan has sponsored over 40,000 students to study at Australian HE institutions (Strategy Policy and Research in Education Limited, 2009).

In 1985, the government introduced a new overseas student policy. Universities may admit international students who meet the entry requirements and pay full tuition (Smart & Ang, 1993). The new policy led to a dramatic increase in international student enrolment for three reasons (Knight, 2015). First, Australian HE has a good reputation and is perceived as world-class, but its entry requirements are lower than top-ranked universities in other countries, such as the United States (McCrohon & Nylan, 2018). Second, the excellent employment and career prospects after graduation help attract many students to study in Australia (Lin-Stephens et al., 2015). In Australia, many skilled occupations, such as nurses, accountants and engineers, are always in high demand, but this demand is not met by Australia's domestic supply (Salmi, 2009). The migration policies allow students with qualified skills to work and live permanently in Australia after graduation (Brett & Pitman, 2018). Third, the cultural, social and natural environment of Australia attracts many international students (Briguglio & Smith, 2012). Because of Australia's long history of migration, well-established communities from various cultural and ethnic backgrounds have allowed international students to maintain ties with their origins while studying in Australia (Anderson & Guan, 2018).

Overseas students from various countries bring with them a variety of educational experiences and backgrounds. When universities began to recruit large numbers of international students in the late 1980s, the issues of academic and language readiness became diverse and complex (Agosti & Bernat, 2018). In response to the growing number and needs of international students, many universities have seized opportunities to establish public pathway providers and/or enter into commercial agreements with private providers in order to increase the participation of international students in Australian HE (Velliaris, 2019). Various programmes, such as English-language programmes, foundation studies and diplomas, were created to meet the various needs of the students.

English-Language Programmes and Diplomas. In 1984, almost simultaneously with the introduction of full-fee-paying international students, the first English-language programme was established. UniSearch, a private provider, provided English-language programmes for international students whose English levels were insufficient for direct admission to the New South Wales Institute of Technology (later renamed the University of Technology Sydney [UTS] in 1988; Fiocco, 2005). Later, the English-language programme was combined with the additional academic content of business and information technology, which was then accepted as satisfying both the English-language and academic entry requirements for the two undergraduate programmes (Fiocco, 2005) at UTS. The initial curricular framework for the subsequent diploma programmes was developed by combining academic and English preparatory content in a single programme.

English-language programme and diplomas continue to be popular study options for international students. The English-language programmes fulfil their mission of providing students with English proficiency in order for them to succeed in HE. The diploma programmes primarily address academic preparedness for students who do not meet the traditional academic entry requirements for Australian HE. Universities later realised that certain markets were inaccessible because students with secondary-school diplomas from countries like Pakistan, Indonesia and Vietnam were not recognised in the traditional university admission pathway (Velliaris, 2019). As a result, diplomas have become the primary admission pathway for these students to access Australian HE.

Foundation Studies. The University of New South Wales (UNSW) created the first foundation studies programme in 1988 (O'Halloran, 2004). The original participants were 400 Indonesian nurses. The success of the programme prompted the University to see an opportunity for "a focused programme of academic, cultural, and language preparation for international students" to access HE, but more importantly, "equip them with the skills and confidence to go on and succeed at university" (O'Halloran, 2004, p. 6). UNSW continues to offer foundation studies, and such a curricular structure influences other universities or providers to offer similar programmes (Adams, 1988; O'Halloran, 2004).

Foundation studies continue to be a pathway for international students to enter Australian HE. Most foundation studies students are from China because many do not want to take the stressful Guokao, the National College Entrance Examination (NCEE), in Year 12 and instead choose foundation studies (O'Halloran, 2004). The programme is also popular among students from Malaysia, Sri Lanka and Singapore, where the British education system is prevalent. These students, who complete the General Certificate of Education: Ordinary Level examinations in Year 11, do not wish to take the Advanced Level examinations and instead choose to study in Australia sooner (Fiocco, 2005).

The number of international students in Australia continues to rise as a result of both the 'aid to trade' policy and the emergence of different pathway programmes. The number of enrolments increased from around 2,000 in 1986 to around 70,000 in 1994 (Walters, 2011), 242,504 in 2010 and 418,168 in 2020 (Ferguson & Sherrell, 2019), making education Australia's second largest export industry, just behind natural resources. At least one in five students at most Australian universities is a full-fee-paying international student (Ferguson & Sherrell, 2019). Income from these full-fee-paying students has become a financial lifeline for every university, particularly in an environment of constrained budgets and increased competition among local and international HE institutions (Choudaha & Chang, 2012). As a result, attracting and expanding international student enrolment in HE through pathway programmes remains the top priority for many Australian institutions (Agosti & Bernat, 2018).

Pathway Programmes for Domestic Students

In the 1980s, the Australian HE system had three tiers: i) universities established by Acts of Parliament (e.g., the University of New South Wales), ii) institutes of technology (e.g., the New South Wales Institute of Technology) and iii) colleges of Technical and Further Education (TAFE). In 1987, John Dawkins, the Federal Minister for Employment, Education and Training, reviewed the HE sector (Dawkins & Holding, 1987) and emphasised the importance of establishing the capacity and effectiveness of the higher education sector. His suggestion was for fewer but larger universities. In terms of 'fewer', the former three-tier system was reduced to a two-tier system with only universities and TAFE. Those institutes of technology were given the option of merging with existing universities or becoming new universities. For example, the New South Wales Institute of Technology became the University of Technology Sydney (UTS). As a result, the total number of HE institutions fell from 73 to 38 (DET, 2015); this number later increased to 43 (TEQSA, 2020). 'Larger' simply means that universities were expected to enrol more students "to deliver increased numbers of graduates" (DET, 2015, p. 11).

Bradley (2008) conducted another significant HE review, which resulted in a significant increase in student enrolment in Australian HE. Bradley's review questioned "whether education is structured, organised and financed to position Australia to compete effectively in the new globalised economy" (Bradley et al., 2008, p. xi). According to the review, the HE system should ensure that future generations have the necessary skills and knowledge to work and live in a globalised world. This emphasis is consistent with Sustainable Development Goal 4: Quality Education and 8: Decent Work and Economic Growth adopted by the United Nations (United Nations, 2016). The review also warned that if the government does not increase student enrolment in HE, Australia will become uncompetitive in terms of performance and investment compared to universities in other developed countries. Bradley's (2008) recommendations also emphasised increased social inclusion to ensure the participation of students from a variety of disadvantaged backgrounds, including women from non-traditional fields, people with low socioeconomic status (SES), people from regional and remote areas, people with disabilities, people from non-English-speaking backgrounds and Indigenous people. Previously, these equity groups had fewer opportunities to access traditional entry pathways and succeed in HE (Altbach et al., 2009; Bowers & Bergman, 2016; Smit, 2012).

Since then, increasing domestic student participation has been prioritised in all HE-related policies and agendas. The message of improved skills and job prospects was used to encourage domestic students to pursue undergraduate degrees (Farr-Wharton et al., 2019; Rissman et al., 2013). By 2025, the government hopes that 40% of the population aged 25–34 will hold a bachelor's degree or higher (Bradley et al., 2008). To help HE institutions meet this target, the government lifted the cap on undergraduate enrolment in 2012, transitioning from an elite- to a demand-driven system in undergraduate education. Universities can admit as many students as they wish. The collective effort of these actions has resulted in an upsurge in enrolment (O'Brien, 2020). The number of domestic students increased from 771,932 in 2008 to 1,014,027 in 2018. As of 2019, the proportion of adults aged 25–34 with a bachelor's degree or higher increased to 40.6%, up from 31.9% in 2008 (Australian Bureau of Statistics, 2020), meeting the target of 40%.

The direct result of increasing student participation was the recruitment of students with lower admission scores to HE (Velliaris, 2019). Many students with lower admission scores also fell into one or more of the previously mentioned underrepresented groups. According to Brett and Pitman (2018), the increase in the number of students with poor academic performance has prompted concern in the HE sector regarding better preparing these students to succeed. As universities have other targets to achieve, such as research excellence, many lack the capacity to meet the needs of these students. The situation has resulted in a renewed emphasis on pathway programmes previously available only to international students, resolving the issues brought on by the increase in domestic students (Devlin & O'Shea, 2012; Goldingay et al., 2016; Harvey et al., 2016).

Most providers, including the study's research site, UTS College, offer diploma programmes to domestic students. Some provide customised programmes, such as the tertiary preparatory programme (e.g., the University of Notre Dame) and the enabling programme (e.g., the University of Newcastle). Despite their various names, structures, entry requirements and study durations, these programmes all share a common goal: to improve these students' academic readiness for success in HE (Klinger & Murray, 2012; Morison & Cowley, 2017). The growing student participation in Australian HE continues to affect the long-term viability of pathway programmes for domestic students. By 2015, at least 35 pathway programmes across the country were available to domestic students (Baker & Irwin, 2015).

Characteristics of Pathway Students

Similar to first-year university students, pathway students experience changes in the learning environment. These changes include transitioning from secondary schools or other post-secondary institutes, whether local or overseas, to an Australian HE institution. Still, compared with students who gain direct entry to universities, pathway students are recognised as being ill-prepared for universities. They generally possess the following characteristics.

Lower English Proficiency. International students in the pathway programme may have lower English proficiency than their peers who enter university through direct entry. A minimum

English entry requirement at UTS is an International English Language Testing System (IELTS) academic score of 6.5 overall, with a writing score of 6.0 or higher (UTS, 2023a). The minimum English entry requirement at UTS College is an IELTS score of 5.5 overall, with a minimum of 5.0 in all bands (UTS College, 2023). The difference in entry requirements suggests that international students in pathway programmes may have a lower level of language preparedness and will need more academic communication support to succeed in their studies.

Lower Prior Academic Achievements. As reflected in the admission requirements, pathway students generally have lower prior academic attainments than direct entry students at the university. This characteristic applies to both domestic and international students. Domestic students are admitted to universities based on their academic performance, which is reflected in their Australian Tertiary Admission Rank (ATAR). The ATAR can be any number between 0.00 and 99.95, indicating a student's position in relation to all other students. For example, a student with an ATAR of 90.00 is in the top 10% of all students (Grattan Institute, 2021). Most programmes at UTS require an ATAR of 80 or higher, and no student is normally admitted with an ATAR of less than 69 (UTS, 2023b). According to Baik et al.'s (2019) research, ATARs below 70 are considered low. Academic entry requirements for domestic students in pathway programmes may differ from one provider to the next. Some pathway programmes, including UTS College, have no ATAR requirements because they accept students who have not completed Year 12 in high school as well as mature students (Morrison & Cowley, 2017). The diploma programme's entry requirements centre on high school average marks in High School Certificate (HSC) subjects, including English, plus three other subjects (UTS College, 2021).

Academic entry requirements for international students vary by country for both pathway providers and universities. For example, in Indonesia, universities and pathway providers require different levels of qualifications (tertiary vs secondary) for admission. Overseas applicants from Indonesia must have completed at least one full-time year at the bachelor's degree level at a recognised university or tertiary institution before applying to UTS. For admission to UTS College, Indonesian applicants only need to complete Sekolah Menengah Umum (SMU) Year 3 (equivalent to 'General Middle-Grade School') with an average of 70 marks in academic subjects (UTS College, 2023). The example of Vietnam also highlights the differences in entry requirements between the university and the college in terms of academic performance and educational background (elite vs ordinary schools). Applicants from Vietnam must have a minimum GPA of 8.0 and have completed the Vietnamese High School Graduation Certificate. Applicants must be from one of the country's elite schools. To apply for UTS College, on the other hand, applicants from Vietnam need only to complete Year 12 with a minimum GPA of 6.7, and they can come from any school in the country (UTS College, 2023).

More Students from Underrepresented Backgrounds. Many domestic students enrolled in pathway programmes may also fall into equity groups, including those with lower socioeconomic status (SES), Aboriginal and Torres Strait Islander people and people from non-English-speaking backgrounds (Morrison & Cowley, 2017). Students from these equity groups may face financial pressure and access and inclusion issues, in addition to academic and communication challenges.

This section first defines pathway providers and programmes before discussing the rise of pathway programmes for international and domestic students. More importantly, the background demonstrates that pathway students are more likely to be underprepared for HE studies and vulnerable to unfavourable academic events, one of which is attrition. The discussion of attrition and (dis)engagement continues in the following section.

Pathway Students: Attrition and Engagement

This section focuses on two constructs of pathway students: attrition and engagement. Attrition is defined in the next subsection, along with its benefits and drawbacks. The next subsection discusses the nature and definition of student engagement before examining the connection between engagement and attrition. Finally, the section recognises the critical role that teachers play in increasing student engagement and reducing attrition.

Student Attrition

Attrition, also known as dropout, is commonly understood as the premature departure of students from a programme. The Tertiary Education Quality and Standards Agency (TEQSA), Australia's independent national quality assurance and regulatory agency for HE, offers an official definition of attrition: "the proportion of students commencing a course of study in a given year who neither complete nor return in the following year. It does not identify students who postpone or transfer to another institution" (TEQSA, 2021, Glossary). Unlike the traditional definition of attrition, in which students drop out of a single programme at a single institution, TEQSA's definition emphasises that these students who drop out have no intention of returning to other programmes at the same or another institution to continue their education.

The Good and Bad of Attrition. It is generally agreed that some attrition of pathway students can be 'desirable' and 'positive' (Farr-Wharton, 2019) for HE institutions. Being 'desirable' implies that the pathway programmes have effectively acted as an academic filter, sifting out the incapable students and sending the capable ones to universities. This filter has the potential to improve student attrition data from undergraduate programmes at universities (Hodges et al., 2013). Attrition, however, can also be detrimental to pathway providers (Farr-Wharton, 2019). It may harm pathway providers financially because investments in student development have been made, and subsequent years' tuition fees from those admitted students are lost (Naylor et al., 2017). Institutions with consistently high attrition rates may suffer reputational damage if they fail to achieve their mission of connecting prospective students to HE (Fincher, 2010). Student attrition has a long-term negative effect on the government's goal of having a population with a significant proportion of degree holders, hampering the country's future economic development (Llena-Nozal et al., 2019).

Similarly, attrition has both positive and negative effects on students. Attrited students still gain some knowledge and skills, which could increase their chances of employment and further education later in life (McInnis, 2000). Most attrition, however, is detrimental to students (Farr-Wharton, 2019). Students are more likely to suffer emotional harm (e.g., low self-esteem), fewer opportunities for social mobility and barriers to knowledge-based careers, all of which negatively affect their future development (Kuh, 2007; O'Brien, 2020; OECD, 2020; Tinto, 2012). Furthermore, pathway students may face greater opportunity costs, such as time and tuition fees.

A time commitment is a significant opportunity cost. A pathway programme may require more time to complete than an equivalent undergraduate programme at the university. Full-time students at UTS typically finish their first-year undergraduate programme in two semesters (8 months; UTS, 2023c). At UTS College, students typically take longer. Students in the diploma programme are assigned to two- (8-month), three- (12-month), or four- (16-month) semester programmes based on their prior academic and English achievement. More than 85% of diploma students at UTS College take three- and four-semester programmes, implying that when students leave the programme prematurely, they may have already committed for a longer period with nothing on which to fall back (Morrison & Cowley, 2017). The student could have used the time to pursue other courses and training that would have provided them with the skills and qualifications needed to pursue a career or interest (O’Brien, 2020).

The financial effect of attrition is another opportunity cost. Pathway students contribute more money than first-year university students. International students pay full fees, regardless of whether they attend universities or pathway providers and receive no financial assistance from the Australian government. Domestic students, regardless of whether they study at universities or pathways, receive government loans to pay their tuition fees (UTS, 2023d). Still, the fees for pathway programmes could be three times higher than those for the university’s equivalent programmes. Many domestic students fall into the equity group, such as those with low socioeconomic status (SES). As a result, attrition may have a greater effect on pathway students than on direct entry university students.

Student Engagement

Though the term *student engagement* is “broad, and there is no agreement on its meaning, definition, or measurement” (Mamun et al., 2016, p. 381), most scholars agree that it refers to students’ active participation in learning. Earlier definitions of learning involvement focused on behaviours like attendance (Finn, 1989). Recently, the construct has been expanded to include aspects involving emotions (e.g., a sense of belonging, positive and negative affects) and cognitions (e.g., psychological investment, effort and persistence) to reflect a student’s whole experience of learning (Ding et al., 2018). As a result, the modern definition of student engagement recognises three dimensions: emotions or affect, behaviours and cognitions (Fredricks et al., 2004; Ostrom, 1969).

Student engagement is naturally malleable (Fredricks et al., 2004). Internal factors like motivation, as well as external factors, such as the learning context and interactions with teachers and peers, can all influence student engagement. Although some factors are more stable than others, these internal and external factors can fluctuate, requiring or resulting in changes in student engagement (William & Ivey, 2001).

The changeable nature of engagement is in fact a positive phenomenon because strategies or interventions that address underlying factors of engagement can result in a positive change in student engagement (Hardré & Sullivan, 2009). Changes in student engagement can have multiple consequences, both proximal (e.g., attrition, interest and performance) and distal (e.g., degree completion time and future career prospect), for HE students. Proximally, when students become engaged, they are more likely to be interested in the course participation and motivated to learn, e.g., participate actively in class discussions, complete assignments on time and perform better in assessments (Kahu, 2013; Krause & Coates, 2008). Thus, the overall retention rates could be increased. Distally, engaged students are more likely to progress smoothly, completing their degrees on time, and they are also more likely to develop relevant skills, knowledge and experiences that can positively affect their employability (Martin, 2008; Tinto, 1993). Thus, the malleable nature of student engagement provides hope and a foundation for researchers and educators to support student engagement in order to potentially improve the proximal and distal student outcomes mentioned above, including student attrition.

The Inherent Link Between Student Engagement and Student Attrition. Attrition causes more harm than good to all parties, as discussed in the previous section. Many government policies affirm the critical role played by student engagement in improving attrition. These policies include the Higher Education Standards Framework (Threshold Standard) 2021 (Commonwealth of Australia, 2021), sector reporting, Improving Retention, Completion and Success in Higher Education (Commonwealth of Australia, 2017) and the guide to good practice, Improving Retention and Completion of Students in Australian Higher Education (TEQSA, 2020b). Student engagement is viewed as a supportive way to provide students with opportunities to complete and succeed in their studies in order to reduce attrition (Farr-Wharton, 2019).

Previous research has also confirmed the importance of student engagement in reducing student attrition. Most research on student experiences focuses on undergraduate or postgraduate students (e.g., Baik et al., 2019; Tinto, 2012), with some focusing on pathway programmes, specifically the Enabling Programme (EP) or Tertiary Preparation Programme (TPP; e.g., Bedford, 2009; Hodges et al., 2013; Morrison & Cowley, 2017; Whannell et al., 2012). Currently, there is a scarcity of literature conducted in the context of the diploma pathway. As a result, the current understanding of student attrition in diploma programmes is largely based on previous research on EP/TPP and first-year undergraduate students.

EP and TPP Studies. While EP, TPP and diplomas are all part of pathway programmes, EP and TPP may differ from diplomas. EP and TPP are aimed at students who do not have a formal secondary-school qualification, such as those who did not complete Year 12 in high school. Diploma programmes, on the other hand, at least those offered by Australia's three largest providers—UTS College, Monash College and UNSW College—require students to have completed Year 12 or its equivalent (Morgan, 2018). As a result, while the EP and TPP student attrition studies may be relevant and applicable to diploma students, caution must be taken when interpreting the findings.

Bedford (2009) explored EP students' perceptions of factors influencing their decision to drop out of the University of Southern Queensland, Australia. According to his research, students reported difficulties participating in the EP programme due to time-management issues, expectation issues, poor study-management skills, an inability to remember information and a lack of belonging to the learning community. Whannell et al. (2012) discovered that discontinuing students typically have poor study-management skills, a lack of goals and low motivation to study, leading to disengagement and attrition. Hodges et al.'s (2013) study sought to identify strategies for improving student retention. Their findings also showed that EP students who dropped out of their programmes were less likely to use the university's resources and engaged with their peers and teachers. Similar to the findings of previous studies, Morison and Cowley's (2017) study on EP students revealed that time management, the use of support services and student engagement were key factors influencing the students' decision to drop out of their studies. To address the disappointingly high attrition rates, all the above studies recommended focusing on improving student engagement.

First-Year Undergraduate Studies. Many Australian studies have been conducted on undergraduate student attrition (e.g., Herbert et al., 2020; Kee et al., 2022), but Baik et al.'s (2019) study is most relevant to pathway students. Baik et al. (2019) examined the experiences of 774 first-year undergraduate students at eight Australian institutions who had a low ATAR—i.e., less than 70. Thus, Baik's (2019) study is very similar to the background of pathway students.

Baik et al.'s (2019) findings confirmed that students with low ATAR scores lack academic preparedness. Many low ATAR students stated that their previous school experience or final school year did not adequately prepare them for university study. As expected, low-ATAR students received lower marks than higher-ATAR students in their first year. Low-ATAR students, on the other hand, tended to outperform their expectations of the marks they would receive, implying that they have lower perceived confidence than high-ATAR students.

Furthermore, Baik et al.'s (2019) study discovered that low-ATAR students had low engagement in university learning. They were less likely to participate in their university orientation programmes based on their behaviour. They did not study or collaborate on assignments with other students. Cognitively, many people reported difficulties with time management and managing their workloads. They reported greater difficulty understanding study materials. Emotionally, they were less likely to consider orientation activities useful for a good start. Overall, they were less likely to enjoy their courses. They did not find their courses intellectually stimulating, even though the universities provided them with a wide range of subject options that fit well together. They did not feel a part of the learning communities during their studies. Low-ATAR students were more likely to defer and drop out than high-ATAR students, citing fear of failure, emotional well-being, financial reasons and the university not being what they expected as the main reasons. Baik et al.'s (2019) study, like the EP/TPP literature, suggests encouraging student engagement as a strategy for assisting students with poor academic preparedness.

Drawing on government policies and the studies mentioned above, student attrition and student engagement are inextricably linked. Students who dropped out or intended to drop out were not academically prepared, which negatively affected their engagement in learning. It should be noted that none of the studies discussed above were conducted in the context of pathway diploma programmes, implying that more research is needed. In line with the recommendations made in the preceding studies, which aim to reduce student attrition or promote student retention, the current study focuses on encouraging students to participate in their studies.

The Pivotal Role of Teachers in Student Engagement. While many factors could influence student engagement, teachers' beliefs and practices appear to be the most critical one. According to Zepke et al.'s (2010) study, over 90% of first-year student respondents in New Zealand perceived that university teachers had a much stronger influence than other factors, such as students' self-motivation or family support. Other studies support the importance of teachers in increasing student engagement in HE. Mearns et al.'s (2007) Australian study on human biology practical sessions found that when the teacher was seen to be approachable, devoted to catering to students' needs and well prepared in the teaching, students could get more out of their learning, showed a higher commitment to their learning and were more likely to express their own views. In a U.K. study, Bryson and Hand (2007) discovered that students were more likely to engage if they found teachers who engaged them with the curriculum and pedagogy. In a large study based on data from 6,700 students and 5,000 teaching staff members on 30 U.S. university campuses, Reasons et al. (2006) discovered that the academic support provided by teachers can significantly improve engagement and academic performance in first-year students compared to teachers who did not provide it. A more recent Australian study by Farr-Wharton et al. (2018) on 363 university students found that the teacher–student relationship had a follow-on effect on student engagement and was significantly related to students' intention to drop out of university. As supported by these studies, teachers and their teaching practices are central to the promotion of student engagement (Kuh et al., 2006).

This section affirms the critical role student engagement plays in reducing student attrition; importantly, teachers and their practices appear to be the most influential factors in enhancing student engagement. The next section elaborates on the added layer of challenge during the pandemic: online learning.

The Challenges of Emergency Remote Teaching

The section defines ERT and the variants of online teaching and learning before delving into the three aspects of learning challenges that students face.

Definition of Emergency Remote Teaching

Emergency remote teaching (ERT) is defined as a "temporary shift in instructional delivery mode due to crisis circumstances" (Hodge et al., 2020, para. 13). As the name implies, it is a form of distance learning in which the teaching occurs in a different place from the learning, providing access to learning for students who are geographically distant (Moore et al., 2011). ERT is not a new concept. The University of London offered ERT to those serving in the armed forces during World Wars I and II (University of London, n.d.). In fact, the university pioneered long-distance learning in 1858, allowing students to study for degrees and take exams without having to travel to London (University of London, n.d.). Before the internet, teaching and learning activities took place through print-based correspondence and were then supplemented with recordings on video tapes or lecture videos broadcasted on public TV channels (Daniel & Stroud, 1981). Teachers and students could communicate via mail, fax or telephone (Williams et al., 1998). With the advent of the internet and web-based technologies, online platforms have become common and popular for teaching and learning activities (Motiwalla & Tello, 2000). Nowadays, most distance learning takes place via the internet, and it is sometimes simply referred to as *online learning* (Conrad, 2002; Kahu, 2013). An alternative name for online learning is *e-learning* (Siemens et al., 2015). During the pandemic, most ERT provided by HE institutions in Australia and other developed countries was conducted online (Pearson, 2020). In ERT, teachers facilitate teaching and learning by designing and implementing activities using websites, software (such as Zoom and Microsoft Teams) and learning management systems, such as Canvas, Blackboard and Moodle (Kearney et al., 2020). As a result, activities like teaching and learning solely through standalone educational software programmes and broadcast television are not considered online learning (Means et al., 2009). Based on the preceding discussion, DeCoito and Estaiteyeh's (2022) definition, of "online learning as a specific form of distance or remote learning, is the process of learning with some or all instructions delivered over the internet, with the teacher facilitating the process by structuring and sequencing the online activities" (p. 1), is appropriate to use for describing ERT for the current study.

Within online learning, the mode of delivery can be asynchronous, synchronous or both (Coogle & Floyd, 2015). A *synchronous environment* implies that the teacher and students are both logged on at the same time and that teaching and learning activities take place in real time (Vivolo, 2019). Typically, tutorials are held synchronously via online video meeting platforms, for example Zoom, to allow students to interact with their peers and the teacher (Park & Shea, 2020). Students interacting with others in a small group setting in a real-time environment was thought to be critical to promoting student connections (Heflin et al., 2017).

An *asynchronous environment* implies that learning occurs independently of the teacher and one's peers (Coogle & Floyd, 2015). During ERT, most face-to-face lectures were replaced by recorded lecture videos. Because the videos were asynchronous, domestic students could attend lecture content during university closures, and international students in different time zones could access the lecture content. Some teachers created and used other learning activities to supplement, reduce or replace the asynchronous lecture videos. These activities, such as shorter video clips, e-readings, simulations, quizzes and discussion forums, were available on the learning management system (Tallent-Runnels et al., 2006).

Combining asynchronous and synchronous learning was particularly evident during the pandemic. Due to the support of social interactions in synchronous learning, studies have suggested that having both asynchronous and synchronous learning can provide students with a better understanding of course content than can purely asynchronous learning alone (Siemen et al., 2015).

Challenges Associated with Online Learning

As mentioned in Chapter 1, various reports, including TEQSA (2020c) and QILT (2021), have indicated that satisfaction and engagement were disappointingly low among students whose studies were transferred from face-to-face to online during the pandemic. Understanding the aspects of challenges encountered by students is critical to understanding students' low satisfaction with ERT. Three learning challenges were drawn from the literature, especially those conducted during the pandemic. Each subsection below provides a definition of the learning challenge, explains how online affordance creates learning challenges for students and discusses the possible causes.

Challenge 1: Sustaining Concentration. Concentration can be defined as the ability of a person to focus deliberate mental effort on what is most important in any given situation (Moran, 2004). Other researchers similarly define concentration as the high level of cognitive effort required to be focused on a specific task (Cicekci & Sadik, 2019; Tsai et al., 2017). Using the essence of these definitions, online student concentration in the present study is defined as the student's mental ability to focus on the online learning activity.

Online Technology from Affordance to Challenge. It is understood that learning requires adequate concentration, whether students study online or face-to-face. Teachers can use various pedagogical and instructional strategies with online technology to allow students to focus on learning (Higgins et al., 2019). Teachers, for example, can deliver pre-recorded lectures asynchronously and live lectures via real-time communication tools like Zoom to provide student–content interaction (Bell et al., 2014). Interactive activities, such as games, simulations, models, concept map creation and quizzes, can also be used to support student interactions with course content (Chen & Levinson, 2006; Cook & Steinert, 2013; Smith et al., 2018). Live tutorial activities and workshops can help students build knowledge and skills by interacting with others (Cook & Steinert, 2013).

Disappointingly, studies conducted during COVID have revealed that, for students, maintaining concentration in online activities, whether asynchronous or synchronous, is a challenge. In Asgari et al.'s (2021) study of 627 engineering students' online experiences in the United States, approximately 70% of respondents reported difficulty maintaining their focus during online learning. A Kenyan study found a similar result, with 70.2% of 294 health-science students reporting decreased concentration when learning online (Kabare et al., 2021).

Possible Causes. A review of the relevant studies identified four factors contributing to student focus loss when learning online that are discussed below: long durations, teacher-centred pedagogy and the quantity and quality of instructional guidance.

Long Durations. According to previous studies (e.g., Koi-Akrofi et al., 2020; Simamora et al., 2020), having long hours of online learning contributes to students' losing focus. Most of the time, students sat in front of the screen for extended periods of time without doing anything (Koi-Akrofi et al., 2020). The long duration is especially, difficult for those who have never previously experienced long hours of online learning with insufficient breaks between sessions (Simamora et al., 2020).

Teacher-Centred Pedagogy. The findings in Simamora et al.'s (2020) study indicated that teachers reading the text on the screen endlessly, explaining concepts in a rushed manner and lacking interaction with students contribute to a lack of concentration in students. Mustapha (2021) discovered similar results, revealing that students found it challenging to stay focused if the lecturer did not provide interesting materials and presentations during the lecture session. Some students also believed that teachers lacked preparation. Teachers either did not plan online activities well or did not plan any activities at all. The findings suggest that, when teachers use methods to make activities and learning more engaging, students are more likely to stay engaged in online learning.

Quality and Quantity of Instructional Guidance. Regarding the asynchronous environment, Asgari et al.'s (2021) study identified clarity of design as a factor influencing student concentration. Most students (60%) felt that the instructors' clear guidance or communication on the learning tasks was lacking. When resources are excessive, students can lose focus as well (Ferri et al., 2020). Another scenario is that, when instruction is not concise, correct or direct, students will be unable to understand course materials, resulting in early disengagement (Koi-Akrofi et al., 2020). Students lost focus in synchronous sessions where they were overloaded with information because teachers attempted to cover too many learning outcomes at once (Simamora et al., 2020).

Challenge 2: Effective Collaboration. During ERT, students work together in small groups on the internet or use online tools to complete a task through group discussion and group projects. Therefore, Mark et al.'s (2001) definition of "members' interdependent acts that convert inputs to outcomes through cognitive, verbal, and behavioural activities directed towards organising taskwork to achieve collective goals" (p. 357) on the internet or using online tools is considered appropriate and valuable for the present study.

***Online Technology from Affordance to Challenge*.** While asynchronous learning materials provide students with a wealth of resources and learning flexibility, the asynchronous format is criticised for its lack of student collaboration, resulting in a loss of opportunities to foster intellectual exchanges and social interactions among students (Barber & King, 2016; Oyarzun & Martin, 2013). In an asynchronous environment, creating mind maps and concept maps and contributing to wikis aim to alleviate the problem of lack of collaboration (Chen & Levinson, 2006). The advantages of a face-to-face collaborative environment, such as sharing ideas, discussing issues and receiving real-time feedback from peers, remain lacking (Stewart et al., 2011). As a result, many online courses combine asynchronous and synchronous learning, allowing students to collaborate in real time (Bell et al., 2014). Many collaborative activities took place in Zoom's breakout rooms (McGinn, 2019). Furthermore, the literature suggests that social interactions resulting from collaborative activities may have been more important during the pandemic, when students had fewer opportunities to connect with peers and teachers due to school closures (Baber, 2021).

Unfortunately, while technology allows the promotion of collaborations among students, teachers have noted that engaging in collaborative activities, both synchronous and asynchronous, is difficult. In Simamora et al.'s (2020) study, teachers observed that not all students were active in the online discussion activities. Many teachers also complained about the lack of student participation in online collaborative activities (Saadati et al., 2021). Students at an Australian university taking an online tutorial during the pandemic made similar remarks about inactive group members (Smith & Kaya, 2021). Students who participated in a synchronous collaborative activity expressed frustration with the burden of completing the entire task without the contribution and support of their group members, who frequently turned off their microphones and cameras (Smith & Kaya, 2021).

Possible Causes. Reviewing the relevant literature has identified two main themes: anxiety and time, both of which inhibit students' participation in online collaborative activities.

Anxiety. In Asgari et al.'s (2021) study, 48% of student participants reported feeling uneasy about turning on their cameras and microphones during synchronous collaborative activities. Some students reported feeling anxious when being observed on camera. Since synchronous learning is typically conducted at home, some may be concerned that turning on the camera could reveal their living situation, indicating poverty or wealth to others (Reich et al., 2020). This visual withdrawal, however, conflicts with the supposed merits of video communication (Castelli & Sarvary, 2021). Turning on the cameras was supposed to give online learners a stronger social presence because nonverbal cues like eye gaze, facial expression, nodding and other gestures can be conveyed (Smith & Kaya, 2021). When these visual cues are missing, members who attempt to communicate with one another to complete a collaborative task suffer (Rooney & Boud, 2019). Some students experienced emotional discomfort or uncertainty when working with 'unknown others', with a fear of negative feedback from others remaining prominent in collaborative activities (Bower et al., 2015; Swan, 2001).

Time. While online collaboration eliminates the need for physical space, students reported that finding time to collaborate with peers outside of synchronous lesson time remains difficult. Rannastu-Avalos and Siiman (2020) discovered that students found it difficult to negotiate a mutually convenient time to work collaboratively. Students in Mustapha's (2021) study provided similar comments where students found it hard to find time to discuss group assignments. Regarding the teacher, Rannastu-Avalos and Siiman's (2020) study also suggested that teachers perceive time as a constraint on collaborative activities. Teachers perceived online lesson time to be more intense; for example, much time was spent at the start of the class dealing with students' technical issues. As a result, collaboration was sometimes not a priority when delivering online education. Instead, much effort was expended in orchestrating the content of the time-consuming online lessons. Other teachers recognise the value of student collaboration but lack the time to implement an effective collaborative breakout-room activity (Smith & Kaya, 2021). In a tutorial of 30 students, allowing each group to have adequate time to report back their key discussion findings, Smith and Kaya had three breakout rooms, each containing ten students. As a result, students complained that they did not have equal or adequate opportunities in the breakout rooms to voice their opinions and provide feedback to others. The large group setting bothered some people because they believed it was inappropriate for collaboration. As a result, this case emphasised the importance of time in online collaborative activities (Chandler, 2016).

Challenge 3: Independent Study. Independent study is regarded as a situation where a student needs to take charge of their learning (Moore, 1973). It is also a soft skill necessary for the future workplace that may not be explicitly taught in school (Heng & Sol, 2021). Independent learners are also more likely to develop and master other soft skills, such as time management, progress management and performance evaluation, which can lead to the development of self-driven learners (Meyer et al., 2008).

Online Technology from Affordance to Challenge**.** Online learning, particularly its asynchronous components, is independent in nature (Azevedo, 2008; Dabbagh & Kitsantas, 2004). Asynchronous learning activities, such as pre-recorded lectures, interactive tasks, assessments and online discussion forums, all necessitate the learner's independent effort (Kearney et al., 2020). This type of activity allows students to learn at their own pace and in their own space (Daniel, 2020). As a result, Broadbent (2017) reported that students use independent skills more frequently than in traditional classroom learning and that this skill is more important for online learning success.

Evidently, the literature review confirmed that many students struggle with independent study during ERT. Many studies have found that students in online learning lack independent skills or capabilities (Hung et al., 2010; Onwuegbuzie & Ojo, 2021; Gu & Sok, 2021). According to the studies, students were unable to self-direct and regulate their learning in pursuit of the expected learning outcomes (Koi-Akrofi et al., 2020). Teachers in some studies commented that students were not self-motivated (e.g., Adnan & Anwar, 2020) and urged students to develop a greater sense of independence and self-discipline (del Arco et al., 2021).

Possible Causes. Reviewing the relevant literature revealed three layers of issues related to independent learning: perceived relevance, students' lack of self-discipline and time-management skills and teachers' instructional design, which has not paid attention to independent learning in order for students to master it and enjoy its benefits.

Perceived Relevance of Topics. Mustapha et al.'s (2021) qualitative study investigated the online learning experience of 118 Malaysian HE students during the pandemic. Their findings indicate that some students found the content delivered online less rigorous and exciting, resulting in their unwillingness to participate in class. Even when students joined the class, they remained silent and paid little attention because the topic did not appear relevant to them. Simamora et al. (2020) found that the issue is not the topic itself but how it is presented to students. Some teachers fail to incorporate content relevance or implication when introducing a topic or concept, which contributes to students' loss of interest in independent learning.

Lack of Self-Discipline and Time Management. Students had more freedom in online learning than in classroom learning (Paudel, 2021), but they struggle to manage their freedom in terms of time management and self-discipline. According to Asgari et al.'s (2021) research, 48% of undergraduate engineering students cited time management and self-discipline as issues affecting their studies. Students in Gu and Sok's (2021) study found it difficult to resist the temptation of other distracting and entertaining activities, such as social media or video games. Procrastination was also a common issue among online course students (Hong et al., 2021). As a result, students miss out on the process and benefits of self-directed learning in an online environment (Kabare et al., 2021).

Teachers' Instructional Designs. It has long been argued that attention to the role of independent learning in online instructional design and delivery is lacking (Abrami et al., 2011). A survey of 893 university students in Spain conducted during the pandemic found that online teaching was carried out with the same parameters as face-to-face teaching. This result demonstrated that teachers did not fully use the benefits of online teaching in the event of ERT. For example, computer-adaptive instruction and the provision of choices that help optimise and personalise the learning experience for individual students were not reported in studies on ERT (Gu & Sok, 2021).

Furthermore, the provision of feedback appeared to be minimal or non-existent in many ERT scenarios (Simamora et al., 2020). Feedback is a driver of independent learning because it allows learners to assess their progress, thereby motivating them to continue their learning efforts (Faber et al., 2017). It is acknowledged that, in the online context, teachers have fewer opportunities to provide immediate feedback to students than in the face-to-face context (Koi-Akrofi et al., 2020). Still, some online features, such as quizzes and discussion forums, are expected to enable teachers to provide students with timely and tailored feedback (Dipietro, 2010; Vonderwell et al., 2007; Dietrich et al., 2021).

As discussed in Chapter 1, reports from TEQSA (2020), SES (2021) and QILT (2021) confirm student dissatisfaction with online learning during ERT. The three challenges encountered by students and their potential causes identified in this section could serve as a starting point for understanding how teachers solve these challenges in instructional design and teaching, which is the aim of this study.

Theoretical Frameworks

In investigating teacher practices to support student engagement in online learning, the current study uses SDT (Deci & Ryan, 2010; see the following subsection for details) to understand how teachers use motivational strategies in their instructional design and teaching to solve the three online challenges that support student engagement: sustaining concentration, effective collaboration and independent learning. To supplement our understanding of teachers' practices, self-efficacy beliefs from social cognitive theory (Bandura, 1977; see 'Self-Efficacy' subsection below) were adopted to explore how teachers gained the confidence and ability to implement various motivational strategies in the abrupt transition from face-to-face to online teaching.

Self-Determination Theory

Deci and Ryan (1985) first introduced self-determination theory (SDT) in their seminal work, 'Self-Determination and Intrinsic Motivation in Human Behaviour'. This motivation theory explains the dynamics of psychological needs, motivation and behaviours in humans within a social context. The theory's overarching idea is that all people have three innate and universal psychological needs: autonomy, competence and relatedness, which motivate them to act or not to act:

- *Autonomy* refers to the desire to feel in control of our actions: i.e., the ability to set our own goals and make our own decisions (Reeve, 2013). When a person's need for autonomy is met, he or she feels self-endorsed and self-governed.
- *Competence* is the mastery of activities (Ryan & Deci, 2017). When the competence need is met, the individual feels effective and capable.
- *Relatedness* is the sense of being connected to others (Ryan & Deci, 2017). Satisfying this need can provide the individual with feelings of warmth, affection and enjoyment.

Notably, according to SDT, when the three universal needs are met, a person's motivational orientation is more likely to shift from amotivation to extrinsic and intrinsic motivation. The intrinsic source of motivation is the underlying force or energy resource that drives students to engage in learning (Reeve, 2013).

Suitability of SDT, A Motivational Theory, for Explaining Engagement. Engagement can be explained by motivational theory. While some researchers use the terms *engagement* and *motivation* interchangeably (e.g., Martin, 2010), the following researchers provide definitions that distinguish the two concepts. According to Appleton et al. (2006), motivation is a student's intention and energy to learn. Engagement, according to Fredricks and McColskey (2012), reflects an individual's interaction within the learning context. Researchers (e.g., Chiu & Lim, 2020; Reeve, 2013; Ryan & Deci, 2017) consider motivation the psychological source of energy underpinning engagement that reflects students' actual learning experiences. As a result, motivation is regarded as a prerequisite for engagement. In this connection, motivational theories, such as SDT, can explain student engagement in the context of learning (Losier et al., 2001).

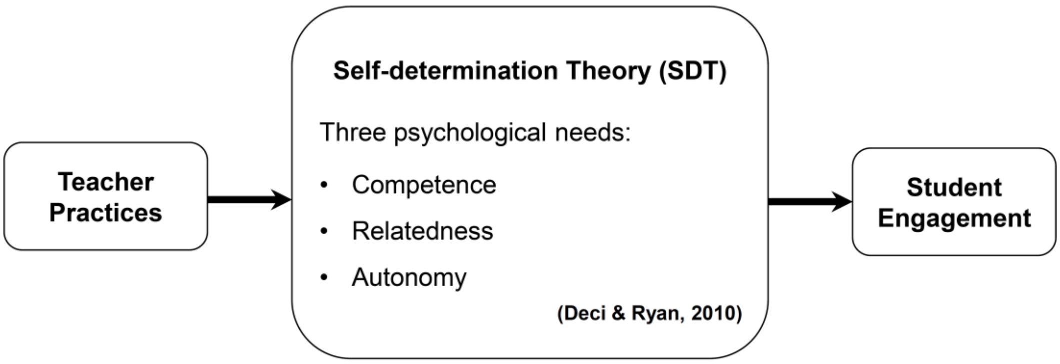
Empirical research also confirms that SDT can explain student engagement. According to SDT, students' psychological needs must be satisfied before they can engage in learning. Needs-supportive practices have been shown to influence all types of engagement. Relatedness-supportive practices, for example, can lead to increased levels of behavioural engagement (e.g., active participation in a lesson), emotional engagement (e.g., positive emotions about the lesson content) and cognitive engagement (e.g., better time management; Bedenlier et al., 2020; Reeve, 2013; Ruzek et al., 2016; Vollet et al., 2017). Certain needs-supportive practices appear to promote one aspect of engagement more than others. Competence-supportive strategies, for example, have been shown to be more influential for cognitive engagement, causing students to develop a sense of mastery over the topic being studied and feel encouraged to complete difficult tasks (Reeve, 2013; Skinner et al., 2008). As such, the current study adopted the same approach used to understand teacher needs-supportive practices to explain engagement.

Other motivational theories can also be used to explain student engagement. The expectancy-value theory is one example (Eccles, 2005). Eccles' (2005) theory emphasises a learner's goals and perceived value as factors influencing task selection and effort level in student engagement. Previous research has used the expectancy-value theory to understand student engagement. For example, Sansone et al. (2011) surveyed 108 undergraduates majoring in psychology to understand the importance of the who, why and how in online learning and discovered that, when the utility value of a task was provided to students, student engagement increased. It is acknowledged that the expectancy-value theory can provide useful insights into how to promote student engagement. Still, SDT, particularly its concern with autonomy needs, recognises the goal and value while also emphasising the importance of intrinsic motivation. Intrinsic motivation is arguably the most important development in the learning journey of any student (Chiu, 2021). This development is critical because, when a person is intrinsically motivated to do something, he or she masters it for the sake of its inherent satisfaction rather than for the sake of some positive or negative consequence, such as a reward or punishment. Learners who are more intrinsically motivated are less likely to disengage, give up learning or drop out of a course (Martin, 2010; Vallerand et al., 1997). As a result, when compared to other motivational theories, SDT may provide a more comprehensive and insightful understanding of how intrinsic motivation can be promoted to engage students and reduce student attrition (Ryan & Deci, 2020).

Teachers' Role as a Contextual Factor in SDT. Contextual factors can have a significant effect on whether a student meets or satisfies their psychological needs (Lietaert et al., 2015). Contextual factors in teaching and learning may include oneself, teachers, peers, family, the classroom and the school environment (Bronfenbrenner, 1979). In a New Zealand study to determine the relative importance of influences on first-year university students' engagement, Zepke et al. (2010) discovered that university teachers have a much stronger influence than other factors, including the learner's motivation and family support. Other studies (e.g., Allen et al., 2013; Roorda et al., 2011; Wang & Eccles, 2012) also evidenced the effect of teachers and their actions on student motivation and engagement. These empirical studies support the current study's decision to focus on teachers and their practices. The preceding relationship among teacher practices, psychological needs and student engagement is summarised in Figure 2.1.

Figure 2.1

Self-Determination Theory (SDT) as a Lens Through Which to Understand Teacher Practices that Support Student Engagement



Previous Studies to Understand Teachers' Needs-Supportive Practices. The global effect of the COVID-19 pandemic has compelled many countries to shift to online university teaching, creating a pressing need for educators to adapt their pedagogy to the new learning environment. This demand has given rise to the concept of 'resilient pedagogy', which emphasises adaptability and mode-agnostic instruction regardless of whether it is face-to-face or online (Gardiner, 2020).

At the core of resilient pedagogy is the principle of being needs-centred, drawing upon the concept of needs from SDT (Deci & Ryan, 2010). Resilient pedagogy aims to design courses that cater to a wide range of student identities and scenarios, addressing the needs of competence, autonomy and relatedness (Gardiner, 2020; Masland, 2021). By doing so, educators strive to maximise the potential of a diverse student body to meet their individual needs effectively.

SDT research is instrumental in guiding the development of resilient pedagogy. While there is extensive SDT research on teachers' practices in the face-to-face context at various educational levels and in various disciplines (Hsu et al., 2019), the literature concerning SDT's application in the online teaching context is currently limited (Bedenlier et al., 2020; Chiu, 2021). The following studies draw on the available literature and specifically explore teachers' needs-supportive practices in online teaching, using SDT as a lens through which to understand and enhance online instructional strategies.

Alamri et al. (2020) investigated the experiences of postgraduate students in two online courses: a one-size-fits-all course and a personalised online course. The study concluded that giving learners choices about learning and providing a relevant curriculum in a personalised online course can help them meet their autonomy needs. Furthermore, the study discovered that relatedness is enhanced when students are allowed to work and collaborate in small discussion groups. Alamri et al.'s (2020) study contributes to the identification of practices in online teaching that meet specific psychological needs.

Chiu and Mok (2017) examined the effect of competence-supportive needs on students' mastery of concepts. They focused on the effects of visual aids in instruction on secondary students' understanding of mathematical concepts. As expected, the results showed that students who were assisted with visual aids outperformed those who were not. What is more important is the mechanism or reasons behind the observations. The study explained that instructions without visual aids required learners to search for and select information that was temporally and spatially dispersed, placing an undue burden on their cognitive load. As a result, an effective online learning environment necessitates teachers' paying attention to the instructional design that can help address students' cognitive load if it is to assist students in meeting their competence needs. Chiu and Mok's (2017) study highlights the importance of managing student cognitive load to meet their competence needs in online teaching.

Later, Chiu and Lim (2020) investigated the effects of various types of technology on student learning in different subjects. He looked specifically at the effects of content-specific technology (e.g., videos and games) and content-neutral technology (e.g., mind maps) on students' learning in subjects with strong cultural elements (e.g., Chinese and English) as well as non-cultural elements (e.g., science and mathematics). The findings indicate that different subjects necessitate different sequences and amounts of content-specific and content-neutral technologies to develop student competence. One important insight from Chiu and Lim's (2020) study is that the types of needs-supportive practices are related to the nature of the subjects, the type of technology and the learner profile, suggesting the need to conduct discipline- and school-level-specific studies.

Some researchers focus on the asynchronous online discussion forum format because it is a novel and unfamiliar learning activity for many students. Xie et al. (2006) examined students' motivations for participating in online discussions. Their study found that teaching students how to use discussion tools, such as creating new discussion threads and replying to messages, can lead to an increased sense of comfort and, eventually, competence. Later, Xie and Ke (2011) investigated the motivations of 23 U.S. students in synchronous online discussions. They discovered that a collaborative learning environment can foster a sense of trust among students, thereby meeting their relatedness needs. Vonderwell et al. (2007) also explored the student learning experience through asynchronous online discussions. Their findings indicated that discussion forums with clear instructions could facilitate students' meeting their competence needs. Their findings also revealed that, when teachers provide students with emotional support, such as pedagogical care, acceptance and assistance in online learning, students can experience warmth, affection and enjoyment, thus meeting their relatedness needs. Importantly, these studies highlight that teachers' provision of additional support to students using unfamiliar online tools can further help students meet their psychological needs in the online learning environment.

While the above studies focus on needs-supportive measures, Hartnett (2015) discovered several needs-suppressing practices when investigating how New Zealand pre-service student teachers' participation in an online course. The study discovered that, when students were presented with unnecessary study content, high assessment pressure and perceptions that the learning activity lacked relevance, their autonomy needs were undermined. Her research also indicated that unclear and complicated instructions, as well as insufficient guidelines and feedback in an online course, would become barriers to students' meeting their competence needs.

Finally, Lee et al. (2015) generalised findings from previous studies and identified three autonomy-promoting strategies relevant to the assessment. These strategies include giving students assignment options, explaining the reasoning behind the choice when time is limited and giving students flexibility in completing more personally meaningful assignments. Their findings provide useful empirical and practical insights into autonomy-supportive practices.

Self-Efficacy

Self-efficacy is a belief system possessed by an individual (Bandura, 1977). Beliefs serve as filters for teachers when making curriculum and instruction decisions (Pajares, 1992); thus, beliefs can determine how and explain why teachers adopt specific strategies in a new teaching environment (Golombek, 1998). There has been an ongoing struggle to distinguish self-efficacy from other related self-constructs, such as self-concepts and self-confidence (Pajares, 2005). Stankov and Lee (2015) used the following quotations to highlight the conceptual differences among the three related yet distinct constructs to resolve this issue:

- Self-confidence: "*I am sure I have done this correctly. Therefore, I do not have to work hard on this, nor do I have to reflect on my decision, because I already know I have done the right thing".*
- Self-concept: "*I am good at this, and this is part of what I am. Therefore, I can do this".*
- Self-efficacy: "*Although this task looks hard, I can do this. Therefore, I should push myself to successfully complete this task no matter how hard it seems to me now".* (Stankov & Lee, 2015, p. 226)

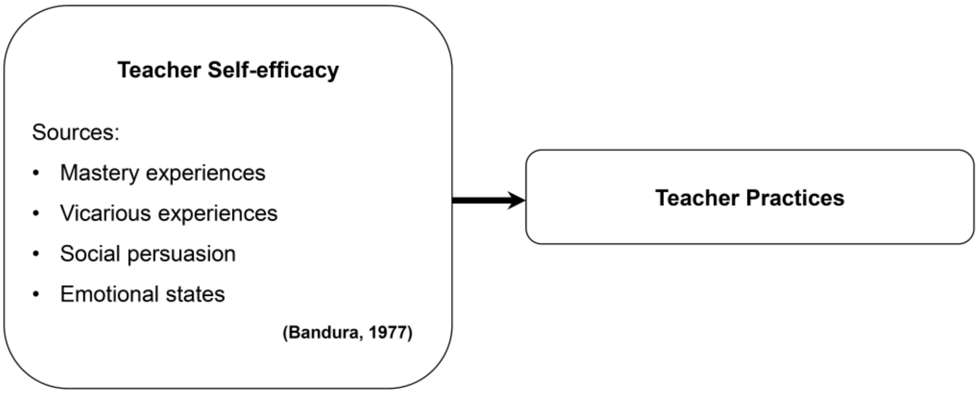
All the statements agree that judging our capability is subjective, as it is based on one's own perception. These statements emphasise two distinct aspects of self-efficacy. First, self-efficacy is situational. The quotation on self-efficacy refers to a specific situation—'this task appears difficult' and 'how difficult it appears to me'—as opposed to the general situation 'this' in the concepts of self-confidence and self-concept. As such, *self-efficacy* refers to our assessment of our ability to complete a task in a given situation. Second, to attain the designated goal 'successfully complete', the concept of self-efficacy contains elements of effort expenditure and persistence when facing challenges, as indicated by 'push myself' and 'no matter how hard it seems'. These elements are missing from the statements about self-confidence and self-concept.

As such, self-efficacy refers to "people's judgements of their capabilities to organise and execute courses of action required to attain designated types of performances" (Bandura, 1977, p. 391). The extent of self-efficacy towards a particular task in a specific situation thus determines how challenges are dealt with and goals are approached. This definition fits the present study, which seeks to understand how pathway teachers' self-efficacy influences their strategies in terms of choice and effort (the second aspect) to engage students in the online environment during ERT (the first aspect).

Sources of Self-Efficacy. According to Bandura (1977), self-efficacy develops from a person's subjective interpretations of events he or she experiences and feels. Bandura (1977) summarised these subjective experiences and emotions into categories known as the four main sources of self-efficacy development (Figure 2.2).

Figure 2.2

Sources of Teacher Self-Efficacy



- *Mastery experience* is a person's first-hand successful experience with and performance on a task. According to Bandura (1977), the definition of 'success' is a subjective interpretation rather than an objective measurement. As a result, the same experience or performance can result in varying changes in the self-efficacy levels in two different people. This suggests that whether such first-hand experience contributes to an increase in self-efficacy is highly subjective.
- *Vicarious experience* is a learning experience gained by observing others who have completed a specific task successfully. The 'others' could be anyone; in education, however, the successful 'others' are usually colleagues, i.e. other teachers. This is especially

important for tasks that the individual has never attempted or completed successfully. As a result, Bandura (1977) acknowledges that the 'others' one observes are critical to the development of self-efficacy.

- *Social persuasion* is others' verbal or nonverbal judgement of our ability to perform a specific task. According to Bandura (1977), both the perceived intensity of the challenge and the perceived nature of the feedback are subjective. When one feels that he or she receives genuine praise and acknowledgement after completing a difficult task, one's self-efficacy increases. If the praise is perceived as false flattery or is for a non-challenging task, there will be no effect on the strength of self-efficacy. When a person receives negative feedback, his or her self-efficacy decreases. Bandura (1977) also considered that the effect of negative, destructive feedback on one's self-efficacy level is stronger than that of positive, constructive feedback.
- *Emotional states* are how an individual feels after completing a specific task. It is acknowledged that an individual's existing level of self-efficacy and perceived level of challenge have an effect on his or her emotional state and thus his or her assessment of his or her ability to complete the task.

Bandura's Self-Efficacy Framework's Suitability for Understanding Teachers' Practices. Bandura's self-efficacy beliefs are based on social cognitive theory (Zimmerman, 2000). This theory describes a critical role for cognitive processes in which a person observes themselves, their peers and their environment, reflects on it in conjunction with their beliefs and knowledge and changes their behaviour as a result. For example, a teacher may implement needs-supportive practices in the classroom because he or she observes others doing so and believes that such behaviour is consistent with his or her beliefs (Bandura, 2011). As a result, social cognitive theory embraces and acknowledges the influences on one's actions of oneself and others in a specific environment. Thus, Bandura's self-efficacy belief framework can complement SDT by providing important cues about how oneself and others in an environment provide teachers with the confidence and perceived ability to implement needs-supportive strategies in their teaching. After four decades of research, Bandura's (1977) four sources continue to be important in influencing the development of one's self-efficacy. Therefore, any research into the development of teacher self-efficacy should draw on these four main sources.

Previous Studies into Sources of Teacher Self-Efficacy. Research has supported the idea that exploring teacher self-efficacy can contribute to a deeper understanding of their teaching practices.

Teacher Self-Efficacy Level and Their Practices. Most relevant studies were quantitative, assessing teachers' self-efficacy in their practices and other outcomes in a face-to-face setting. Zee and Koomen (2016) conducted a systematic review that synthesised findings from 165 teacher self-efficacy studies conducted over the last four decades. The findings indicate that teacher self-efficacy influences instructional designs, practices and strategies to support student learning. Highly effective teachers are better at connecting with students' lives, using differentiated instructional strategies to meet individual needs, experimenting with new approaches to improve their practices and changing their practices to promote student-centred learning. Importantly, teachers with high self-efficacy are more likely than their counterparts with low self-efficacy to use the instructional knowledge and skills gained from professional-development programmes. It should be noted that the contribution of qualitative studies on teacher self-efficacy in an online teaching context to Zee and Koomen's (2016) systematic review was minimal.

In the context of online learning, Kreijns et al. (2013) studied 1,484 primary and secondary school teachers in the Netherlands. They reported that teacher self-efficacy is related to their willingness to try new teaching strategies, such as using digital teaching and learning materials, and that it plays an important role in pursuing goals and overcoming challenges. Similarly, Buchanan et al. (2013) discovered that, when teachers were efficacious in using online teaching tools, they were more likely to use more strategies to motivate and engage their students in learning. Ma et al.'s (2021) study assessed teacher self-efficacy at the start and end of one semester during China's COVID-19 school lockdown. They discovered that, while teacher self-efficacy for online instruction did not significantly increase, it did significantly increase for technology application.

Sources of Teacher Self-Efficacy and Their Practices. Previous studies also tapped into the sources of self-efficacy in teachers. Apart from the four studies below, little has been done to investigate the sources of teacher self-efficacy in the HE online context (Matos et al., 2022). Leonardo et al. (2019) investigated the sources of teachers' self-efficacy at a Brazilian university. The primary sources were identified as mastery experiences (e.g., reflecting on their practices), vicarious experiences (e.g., observing others teach) and verbal persuasion (e.g., receiving feedback). Knoerr (2019) investigated the sources of self-efficacy of French-speaking university teachers when teaching English as a second language in Canada. The participants emphasised the importance of verbal persuasion and emotional states in influencing their sense of self-efficacy. When they received negative student feedback, they interpreted their teaching experiences negatively and felt less capable. Those who thought the student feedback was positive, on the other hand, felt more competent and continued teaching English.

In an Australian study to understand the development of self-efficacy beliefs among HE teachers, Hemmings (2015) revealed that both mastery experiences and verbal persuasion are more influential in enhancing teacher self-efficacy beliefs. Mastery experiences include teaching and public speaking. Verbal persuasion was obtained from feedback from students and peers, suggesting that the feedback provided the teachers with an impetus for reflection. Participants also stated that participating in mentoring activities provided them with verbal persuasion from peers, although excessive demand may adversely affect such quality.

Like Hemmings' (2015) study, Morris and Usher's (2011) study identified mastery experience and verbal persuasion as the most influential sources among award-winning teachers at an American university. Participants in this study, however, always described the two sources together. While asking a generic interview question, such as ‘Tell me a memorable story that would help me understand how you developed the confidence that you have for teaching undergraduates’, may enrich the data collected, the experiences narrated by participants may pose a challenge for researchers in categorising their responses into the four sources. As a result, generic questions will continue to be used but supplemented with additional prompting, probing and confirmatory questions to guide interviewees to respond specifically according to each source of self-efficacy.

Research Gaps

Based on the literature reviewed in the previous and current chapters, research gaps are summarised below:

Current Situation

Online Teaching. As a result of the COVID-19 pandemic in 2020, Australian HE institutions, including UTS College, abruptly shifted to ERT via online approaches. While online learning enabled students to continue their studies during the pandemic, they were dissatisfied and disengaged with their experience. There are reasons to believe that post-pandemic online courses or face-to-face learning combined with online learning will continue (Singh, 2021). For example, combining face-to-face and online elements offers the benefits of both formats, accommodating diverse learning needs. Not only does online education cater to changing educational demands, but it also equips learners with digital literacy and the remote collaboration skills necessary for future work and study. Therefore, more research on student engagement in the online environment is required to guide future teaching and learning design and delivery.

High Attrition in the Science Pathway Programme. While there is a large student population in Australian pathway programmes, many of them are at risk of disengagement and attrition due to their lack of preparation and the challenges of online learning. There has been little research to support student engagement in the context of Australian university pathway programmes, particularly those with a high attrition rate. A good example is the science pathway programme at UTS College. As a result, exploring how to increase engagement and reduce attrition in pathway programmes warrants further studies.

Topics Not Adequately Studied

Needs-Supportive Practice. While the studies reviewed above confirm that SDT is a useful framework for understanding the effects of teacher needs-based support in an online teaching context on student engagement, many were conducted at the school level (e.g., Chiu, 2021) and prior to COVID (e.g., Hartnett, 2015). According to Chiu (2021), who conducted SDT research at the school level in Hong Kong during COVID, there is currently no helpful guidance for satisfying the three needs in designing and implementing online teaching strategies. Ryan and Deci (2020), creators of the SDT, also expressed a desire for more research into how to support students' three psychological needs in technology-enhanced learning. Aside from capturing needs-supportive strategies, it would be worthwhile to investigate the similarities and differences between face-to-face and online teaching in terms of needs-supportive strategies. The answers will reveal whether needs-supportive strategies are resilient in the face of disruption and agile in the transition from face-to-face to online delivery. All of this has implications for post-ERT, where more face-to-face teaching combined with online learning is expected. As a result, it is vital for the current study to explore how teachers implement needs-supportive strategies to address the challenges encountered by students and thus promote their overall engagement in the online environment.

Teacher Self-Efficacy. When teaching was abruptly moved online during COVID, most teachers were unable to engage their students in online learning (Johnson et al., 2020; Ma et al., 2021). My personal observation was that some teachers with no prior online teaching experience, on the other hand, appeared to be more successful in modifying their instructional practices and, as a result, improving student engagement online during ERT. It is thus of interest to learn how these teachers gained self-efficacy for engaging students in online learning. Aside from confirming the teachers' increased self-efficacy, it is also critical to understand how each source (Bandura, 1977) contributed to their increased self-efficacy. It is equally important to understand each source contributes to the growth of teacher self-efficacy generally. The answers to these questions will have insightful practical implications for teachers' self-efficacy in engaging students online.

Contradictory Findings

Teacher Self-Efficacy. Pre-COVID research on teacher efficacy found that, when teachers gained experience in online teaching, their self-efficacy for online instruction increased (Buchanan et al., 2013; Van Acker et al., 2013; Zee & Koomen, 2016). Ma et al. (2021) studied teacher self-efficacy during COVID and discovered that teacher self-efficacy for online instruction did not increase significantly during one semester of ERT. According to Kearney et al. (2020), teacher self-efficacy may be an intrinsic barrier that is deep-seated, enduring, intangible and difficult to shift. Because of the contradictory findings between pre- and post-COVID studies, more research is needed to determine whether teachers' self-efficacy for online teaching has changed. Could the difference be due to context, such as school level, country and the type of online teaching (asynchronous and/or synchronous) provided, or to the research design, such as whether one semester is sufficient for observing changes in teacher efficacy that are deep-seated in nature?

Source of Teacher Self-Efficacy. The studies reviewed earlier in this chapter also suggest that there is no consensus on the primary source of self-efficacy beliefs among teachers. For example, while Hemmings (2015) discovered that both mastery experiences and verbal persuasion could strengthen teacher self-efficacy beliefs the most, Knoerr (2019) discovered that mastery orientation may not be a necessary source of teacher self-efficacy. More clarity is needed regarding the source of teacher self-efficacy for online teaching.

Limitations Resulting from Previous Study Design

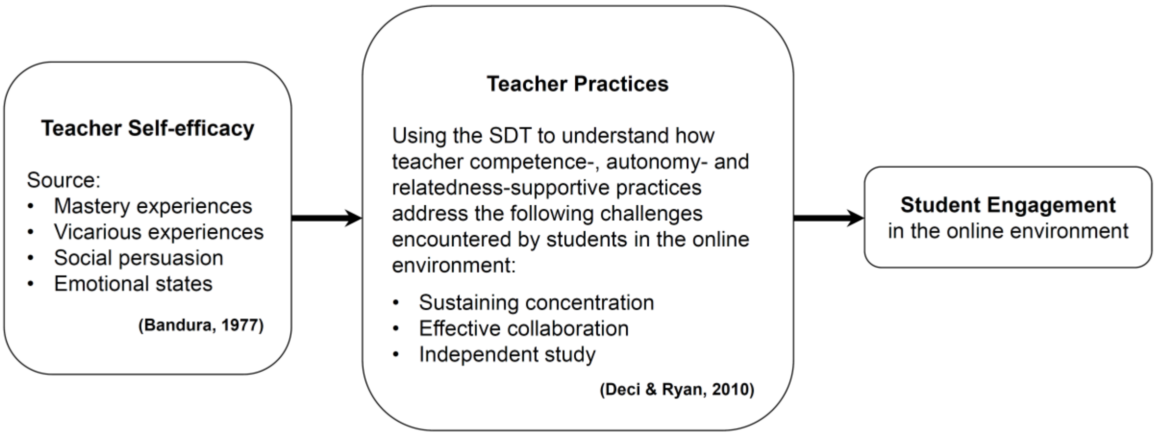
Previous research design has limited our understanding of teacher needs-supportive practice and self-efficacy. First, most existing research on SDT and self-efficacy has relied on quantitative methods, such as surveys and scales, to provide information about the nature of the phenomenon at a specific point in time. The resulting lack of rich detail, however, is the trade-off. Qualitative studies that unearth the thoughts and feelings of respondents (Tondeur et al., 2012) should be conducted to capture the details and help inform new concepts and phenomena (Atkins et al., 2008). Second, SDT and self-efficacy studies based on the perspectives of teachers whose teaching is rated 'excellent' in student feedback surveys appear to be limited (Dunkin, 2002; Kane et al., 2004). Third, as stated in the previous section on teacher self-efficacy, the timing of research is critical in determining the growth of teachers' self-efficacy in engaging students online. There appear to be no studies in the literature that investigate the change in teacher self-efficacy, specifically during the second semester of ERT.

The Present Study

This study aims to address the research gaps discussed above. Guided by two theoretical frameworks—the SDT (Deci & Ryan, 2010) and Self-Efficacy Beliefs (Bandura, 1977; Figure 2.3)—this study explores two topics: teacher needs-supportive practices and self-efficacy during ERT in the science programme at UTS College.

Figure 2.3

An Organising Framework for the Present Study



The overall goal was to address pathway students' attrition in the Diploma of Science by understanding how their engagement in online learning at UTS College can be promoted. The following specific research questions were developed to achieve this goal:

1. How did science pathway teachers support student engagement and success in online learning during ERT, specifically addressing challenges in concentration, collaboration and independent study?

2. What factors contributed to science pathway teachers' self-efficacy for online teaching during ERT?

Chapter 3: Methodology

This chapter explains the methods employed in this study. It begins with a presentation of the interpretive research paradigm and case-study approach for this study. The chapter then discusses the my role as a researcher, research site context and participant recruitment, then explains the various data sources and data-collection procedures used in both the pilot and main studies. The thematic data-analysis strategy is then outlined, detailing the steps taken to analyse and interpret the data. Finally, issues of trustworthiness are addressed before discussing the ethical considerations in conducting this study.

Research Design

Interpretivism

The interpretive paradigm was selected for this study due to its suitability for investigating the complex and subjective phenomena of teachers' strategies and self-efficacy beliefs. Unlike the positivist paradigm, which assumes an objective and measurable social world, the interpretive paradigm recognises the social world as subjective and intricate, encompassing multiple context-dependent realities (Cohen, 2017; Mason, 2002). In this context, teachers act intentionally and make meaning in and through their activities (Blumer, 1969). They can hold "multiple interpretations and perspectives on single events and situations" (Cohen, 2017, p. 17). Hence, this paradigm is better equipped to capture the richness and complexity of teachers' experiences and perspectives.

Epistemologically, the interpretive paradigm is concerned with understanding the subjective world of human experience (Cohen, 2017). To achieve this, research must allow participants to share their frames of reference in their natural settings with the researcher (Mason, 2002). This approach enables me as the researcher to uncover and interpret the social world from the inside, avoiding the imposition of an external perspective (Mason, 2002).

Methodologically, the interpretive paradigm aligns well with a qualitative research approach. Qualitative research aims to understand phenomena in depth rather than quantifying them (Geertz, 1973). This approach involves collecting rich, thick and varied descriptions through interviews and observations to capture the subjective world of human experience. The emic perspective is used to explain and demystify social reality through the eyes of different participants (Creswell, 2009). These characteristics of qualitative research are consistent with the interpretive paradigm's emphasis on understanding the subjective and context-dependent nature of social phenomena.

Given these considerations, the current study used a qualitative approach to explore and understand the meaning teachers ascribe to engaging students in the online learning environment during ERT. By focusing on a small number of cases in depth, the qualitative approach allowed me to capture the complexity and richness of teachers' experiences and perspectives. This approach ensured a comprehensive exploration of the research topic, acknowledging the uniqueness of each teacher's context and facilitating a nuanced understanding of their practices and beliefs.

Case Study

This study adopts a case-study design within the qualitative approach to address its research questions. A case study design is appropriate when the focus is on answering 'how' questions, when researchers cannot manipulate participant behaviour and when the phenomenon and context are inseparable (Yin, 2014). In this study, the research questions aim to understand 'how' teachers' beliefs and practices supported student engagement in online teaching during the COVID-19 pandemic. Additionally, the study observes participants in their natural environment, where the context of online teaching is integral to the phenomenon being investigated. Thus, the case study design aligns well with the study's objectives and constraints.

A case is defined as "some sort of phenomenon occurring in a bounded context' and serves as the 'unit of analysis" (Miles & Huberman, 1994, p. 25). Cases can take on various designs, types and natures, depending on the research context and purposes (Stake, 2000). To comprehend the phenomenon under examination, this study employs a single-case study design, focusing on two teachers' practices and beliefs in engaging students in the online environment.

Yin (2014) identified several rationales for using a single-case design: representative, unique, revelatory and longitudinal reasons. The spatial context is representative, given the prevalence of online teaching during the pandemic. Moreover, the case participants and temporal context are unique, as the study explores how exemplary teachers with limited online teaching experience support student engagement during this challenging period. Additionally, the phenomenon under investigation is revelatory, shedding light on previously under-researched areas, such as teacher self-efficacy and strategies used for online teaching during ERT in the university pathway context. To capture the changes and developments over time, the study is carried out longitudinally throughout the second semester of ERT, offering insights into how teachers implemented their practices and developed their self-efficacy.

The next section will discuss my role as the researcher and positionality in conducting this study. Understanding my role and positionality is crucial for maintaining the integrity and credibility of the research, as it can influence the research process, data collection, interpretation of findings and overall study outcomes.

Role and Positionality of the Researcher

As Holmes (2020) emphasises, my role and positionality are of utmost importance in maintaining the integrity and quality of the research. Transparency about one's background, biases and potential effects ensures that the research is conducted ethically, rigorously and with a keen awareness of its limitations.

As the programme manager who interacts regularly with teacher participants, I recognised that the dual role I hold, as both an administrative colleague and a researcher in this study, could present challenges to maintaining clear boundaries. To address this potential confusion, I took proactive measures to clarify my role as a researcher during the initial meeting, on the Information Sheet and before each interview throughout the data-collection process. This deliberate approach aimed to foster trust with the participants while upholding professional and ethical standards in the research process.

Drawing from my research experience in the EdD programme, I employed repeated interviews, non-participatory observations and email responses to connect with the teachers who participated in this study. My insider perspective as a programme manager and prior experience as a biology teacher at the research site allowed me to empathise with the participants' viewpoints. Nevertheless, I remained acutely aware of the potential for bias and continuously remained open to the diverse perspectives provided by the participants throughout the research process.

By practicing reflexivity, I actively questioned my assumptions, biases and positions as a researcher. I recognised that my prior experience as a biology teacher might influence my interpretations of the data. Hence, I deliberately sought alternative interpretations and engaged with relevant literature to ensure that my analyses remained objective (see further details in the 'Pilot Study' subsection). Engaging in reflexivity was essential to enhancing the trustworthiness of this study's findings (see the 'Main Study' subsection).

Transparency represents another critical element of my positionality that I prioritised throughout the research process (Aguinis & Solarino, 2019). As a researcher, I strived to provide a clear explanation of the research design and methods used, ensuring that the participants were fully informed about the research's purpose and their role in it. Additionally, participants were given the opportunity to review and provide feedback on the research findings, and I maintained meticulous documentation of the research process. By upholding transparency, I aimed to present clear and accurate research findings that contributed meaningfully to the larger body of knowledge in the field.

Research Site Context

UTS College is one of Australia's top two largest pathway providers in terms of student population, programme range and diversity (Morgan, 2018). UTS College has onshore and offshore campuses and offers various pathway programmes, including English-language programmes, UTS foundation studies, graduate certificates and diploma programmes (UTS College, 2023). The present research took place at UTS College in Sydney, focusing on the Diploma of Science programme.

The Diploma of Science programme is designed to prepare students for further studies in science by developing their theoretical and practical knowledge of science, analytical and technical skills and attributes as capable students of science and ethical members of society. The diploma curriculum is aligned with the first-year Bachelor of Science programme at UTS. The learning outcomes and graduate attributes of the diploma are similar or identical to those of the bachelor's programme at UTS. As a result, all subjects in the diploma are considered to be at first-year university level. Students who successfully complete their diplomas will receive 48 credit points towards UTS science degrees (equivalent to one full-year study load) and will be admitted to the second year of UTS's science programme.

Regarding the timetabled lessons, in the pre-COVID era, each science subject typically consisted of a two-hour lecture and a one-hour tutorial on a weekly basis and five to six three-hour laboratory sessions per semester. Both lectures and tutorials were face-to-face and held on the UTS College campus. UTS, not UTS College, managed the laboratory teaching, and face-to-face laboratory activities took place on the UTS campus. As such, UTS College, and thus the present research, focuses on the lecture and tutorial activities but not the laboratory teaching.

During COVID, all classes were moved online. Lectures were replaced in the first semester of ERT by pre-recorded two-hour videos available on Canvas - the learning management system. After the first ERT semester, teachers were encouraged by the College to reduce or replace the asynchronous lecture videos with other learning activities. These activities included shorter video clips, e-readings, simulations, quizzes and discussion forums to replace the lecture content. These modifications were designed to increase student motivation and engagement while learning online. It should be noted that each teacher took the College's advice on replacing lecture videos with other activities to a different extent. Face-to-face tutorials became synchronous online tutorials. As mentioned above, the laboratory teaching is controlled by UTS, and its hands-on practicals have been replaced by video recordings and simulation activities online. As a result, the current study excluded lectures and laboratory learning but focused on asynchronous learning in the learning management system and synchronous tutorials.

Research Participants

Purposeful sampling was employed as the participant-selection method for this study, involving the identification and recruitment of individuals with specific characteristics relevant to the research questions (Gay & Airasian, 2000; Stake, 2000). Initially, in the pilot study, two criteria were used to select 'knowledgeable people': teachers who taught first-year biological science subjects and had consistently high ratings (>4.5 out of 5.0) in student feedback surveys regarding their teaching effectiveness. As the focus and context of the main study shifted, however, the criteria were modified accordingly.

There are two criteria for the main study. The first was to select teachers who taught first-year biological science subjects and had no prior experience teaching online before COVID began. This criterion allowed the research to explore the practices and self-efficacy beliefs of teachers who were new to the online teaching environment. As mentioned in Chapter 1, certain science teachers appeared to be much more eager than their colleagues to revitalise their courses to engage students.

They used other forms of activity to replace lectures in the asynchronous environment and updated their synchronous tutorial materials to make them more suitable for online delivery. Thus, the second criterion involved selecting teachers who were willing to adapt their teaching methods to engage students in the online environment. This adaptability was demonstrated by their creation of more online content in Canvas and their higher ratings in student feedback surveys during the first semester of ERT. By selecting teachers who demonstrated a willingness to adapt and engage students effectively in the virtual learning setting, the study gained illuminating insights into the effective practices of teachers and the development of teacher self-efficacy during this challenging period.

The required information for the first criterion was obtained from the staff intranet, while that for the second criterion was accessible from the Canvas site. Two teachers who met the above criteria were identified from the pool of six teaching staff members and were invited to participate in the study through email communication. To ensure a comprehensive selection process, a contingency plan was in place in case either of the two teachers declined to participate. In such an event, the initial plan was to extend the invitation to other colleagues who also met the same criteria but taught in different science disciplines. This contingency measure was unnecessary, however, as both biology teachers agreed to take part in the study. Table 3.1 provides background information about the participating teachers, and further details on ethical considerations to prevent teacher participation from coercion are available in the 'Ethical Considerations' subsection.

Table 3.1

Participant Details

Teacher	Gender	Age group	Education background	Teaching experience	Information relevant to the participant selection criteria
A	Female	41-50	Bachelor of Science	Total: ~ 8 years • Face-to-face: 4 years at the research site and 3 years at other	**Subjects taught:** • Cell Biology and Genetics (CBG) • Human Anatomy and Physiology (HAP)

				tertiary institutes • Online: 2 semesters	**Previous accolades:** • Technology Innovative Prize (2019) • Learning and Teaching Citation Award (2018)
B	Female	31-40	Bachelor of Science Master of Biomedical Science	Total: ~ 8 years • Face-to-face: 6 years at the research site and 1 year at a language school • Online: 2 semesters	**Subjects taught:** • Biocomplexity (BCY) • Cell Biology and Genetics (CBG) • Human Anatomy and Physiology (HAP) **Previous accolades:** • Technology Innovative Prize recipient in (2018)

Research Data Sources

As Stake (2000) highlights, the use of multiple data sources is a hallmark of qualitative case studies and can significantly enhance the trustworthiness of the study's findings. In this study, three distinct sources of data were employed to address the research questions. Interviews served as a valuable means to capture teachers' perspectives on the strategies they employed and the development of their self-efficacy beliefs. Lesson observations were used to observe the practices implemented in synchronous tutorials directly, while artefacts, such as worksheets and learning materials on Canvas, were examined to gain insights into the strategies that were put into action.

By incorporating multiple data sources, I was able to draw on both observable actions (e.g., strategies used during tutorials) and unobservable intentions (e.g., the sources of self- efficacy beliefs) to achieve a more profound and comprehensive understanding of the phenomena under investigation. The use of interviews allowed for in-depth exploration of participants' thought processes and reflections on their strategies and beliefs, while lesson observations provided concrete evidence of how these strategies were enacted in the online teaching environment. Examining artefacts further enriched the analysis by offering tangible representations of the strategies implemented. Furthermore, the integration of data from multiple sources enabled me to identify patterns and themes in teachers' strategies and self- efficacy beliefs that might not have been apparent if I had solely relied on a single data source, such as interviews alone. By triangulating data from interviews, lesson observations and artefacts, I could cross-reference and corroborate information, enhancing the trustworthiness and credibility of the findings. This approach provided a more robust and comprehensive view of the phenomenon, strengthening the overall trustworthiness of the study's conclusions.

Interviews

Interviews played a central and vital role as the primary data source in this study, allowing for an in-depth exploration of the 'how' elements of the research questions, as emphasised by Yin (2014). Through these interviews, teacher participants had the opportunity to share their perspectives and experiences in their own words, offering a nuanced and detailed understanding of their beliefs and practices, as advocated by Yin (2014).

The semi-structured interview style was purposefully chosen for its flexibility, enabling me to ask follow-up questions based on the participants' responses. This approach allowed for a deeper exploration of specific topics or insights that emerged during the interviews, enriching the data-collection process. Simultaneously, I could ensure consistency by employing the same core set of interview questions for both participants, as recommended by Cohen et al. (2017). This approach facilitated comparability and enabled the researchers to identify patterns and themes across the responses of different participants.

Lesson Observations

The inclusion of lesson observations as a supporting data source in this study served several important purposes. First, lesson observations provided a naturalistic research setting that allowed for the capture of contextual nuances that might have been overlooked during interviews (Cohen et al., 2017). By observing teachers' practices in their actual teaching environments, I could gain valuable insights into the real-world context in which strategies were employed. Lesson observations allowed me to discern the norms and values of each classroom setting, which was crucial for understanding the meanings and relating them to specific contexts and experiences

(Simons, 2014). Understanding the classroom dynamics, communication patterns, organisation of lessons and student interactions provided essential contextual information for interpreting the data and making meaningful connections between teachers' strategies and their instructional environments (Stake, 2000).

Second, the observational data served as valuable evidence to support and corroborate the findings from the interviews. During the observations, I could confirm or refute the strategies that teachers had mentioned in their interviews (Simons, 2014). Additionally, when new strategies were identified during the lesson observations, they served as discussion points for the post-observation interviews, encouraging teachers to elaborate and provide further insights into their instructional practices (Atkinson et al., 2003).

The decision to study video-recorded lessons rather than live lessons was well-justified and had several benefits. First, video recordings allowed teacher participants to have autonomy in choosing which lessons to share or withhold, addressing concerns about potential coercion or discomfort in observing a particular lesson. This approach respected the teachers' agency and contributed to a more comfortable and collaborative research environment. Second, video-recorded lessons preserved the natural setting of the events as a non-participant observation method (Shanahan & Tochelli, 2014). This ensured that the observations were conducted with minimal intrusion or disruption to the teaching and learning process, providing an authentic depiction of the teachers' instructional practices. Additionally, the use of video recordings offered flexibility in scheduling and allowed for multiple viewings to notice aspects of strategies that might have been missed during real-time observations (Rich & Hannafin, 2008; Sherin & van Es, 2005). This allowed me to capture subtle nuances and details that contributed to a more comprehensive analysis of the data. Finally, video recordings were valuable tools during post-lesson interviews, as they helped participants recall their teaching experiences and reflect on their practices (Coffey, 2014).

This visual aid facilitated richer and more accurate descriptions, allowing teachers to offer deeper insights into their decision-making processes and the rationales behind the strategies they chose.

Artefacts

The inclusion of teaching materials, such as worksheets and learning materials available on Canvas, as artefacts in this study proved to be a valuable and enriching data source (Yin, 2014). These artefacts served multiple purposes in enhancing the research process and findings. First, these teaching materials were used as stimuli during the interviews, prompting teachers to provide more detailed explanations of their instructional practices. By presenting concrete examples of their teaching materials, the artefacts encouraged teachers to consider more deeply into their decision-making processes and the rationale behind their strategies (Schoch, 2020). Moreover, the teaching materials served as corroborative evidence (Yin, 2014), providing additional support for the teachers' accounts shared during the interviews. By comparing the information provided in the interviews with the content and structure of the teaching materials, I could validate and strengthen the credibility of the teachers' narratives. This alignment between interview data and tangible teaching materials enhanced the trustworthiness of the study's findings and reinforced my confidence in the conclusions drawn. Furthermore, the inclusion of teaching materials as artefacts enabled a deeper understanding of the context in which teachers operated (Schoch, 2020). Therefore, artefacts facilitated a more in-depth and nuanced exploration of teachers' self-efficacy beliefs and strategies, offering valuable insights into the complexities of their teaching approaches.

The Pilot Study

The Process

A pilot study serves as a valuable step for me to test their data-collection methods and instruments on a smaller scale before conducting a larger study (Malmqvist, 2019). This preliminary study aims to refine and enhance the data-collection process, ensuring that it aligns effectively with the objectives of the main study (Holloway, 1997). In 2019, when face-to-face teaching activities were still being conducted on campus, a pilot study was conducted, allowing for in-person interviews and face-to-face classroom observations. Before the pilot study commenced, the teacher participants were given the Information Sheet (Appendix 1.1) and provided informed consent by signing the consent form (Appendix 2.1). Ethical issues were discussed and addressed (see the section under Ethical Considerations.

The pilot study involved conducting two interviews with each teacher participant. These interviews took place in a vacant classroom at the research site, arranged at a convenient time for both the teacher and me. During the initial interview, I focused on gathering background information about the teachers, including the subjects they teach, educational backgrounds, teaching experiences and survey ratings from students. Subsequently, the interviews included questions concerning the teachers' instructional practices (e.g. What do you do to support student engagement in biology? Could you give me more examples?) and self-efficacy beliefs (e.g. Could you tell me how you build up your self-efficacy through your personal experiences, such as success and failure?). The interviews were audio-recorded to ensure accurate data capture. Each interview lasted approximately 60 minutes, allowing for detailed exploration and understanding of the teacher participants' perspectives.

After conducting the interviews with the teacher participants, I informed them about the observation process and suggested that they record three tutorial lessons. To ensure that the teachers did not feel pressured, they were given the freedom to choose whether to provide more or fewer videos based on their comfort level. To ensure the recording setup was appropriate, I conducted a test recording in the classroom using an iPad to demonstrate how the recording device should be positioned to capture the projected screen within the field of view.

Before commencing the recording of each class, the teachers informed their students that the recording existed solely for research purposes. Importantly, no students objected to the recording.

The teachers then provided me with password-protected USB flash drives containing the recorded lessons, with Teacher A providing two lessons and Teacher B providing three. Each recorded lesson lasted approximately 60 minutes.

During the lesson observations, I used a pro forma (Appendix 3) that contained a list of strategies mentioned by the teachers during the initial interviews. By keeping these strategies in mind while watching the recorded videos (Simons, 2014), I was able to take notes and record practices that were not initially included in the list. This approach allowed me to capture additional insights into engaging strategies used by the teachers, which could then be used as discussion points during the post-lesson interviews.

After observing all five recorded lessons, I invited the teachers to participate in a final interview. These interviews were conducted almost at the end of the semester and followed a semi-structured format, allowing me to follow up on the specific practices observed during the lessons and providing an opportunity for the teachers to elaborate on their experiences further. Each teacher was interviewed in a vacant classroom at a mutually convenient time, ensuring a comfortable and conducive environment for the discussion.

Lessons Learnt

Engaging in reflexivity and critically examining the pilot process is a crucial step in enhancing the rigour and trustworthiness of the main study's methodology. By conducting this self-evaluation, potential issues and challenges can be identified and addressed, leading to improvements in the research process. Despite the differences in format between the pilot study (in-person) and the main study (online), the insights gained from the pilot were instrumental in refining the instruments and ensuring their adequacy for the main study.

This section will present a thorough evaluation of the instruments used in the pilot study. This evaluation aims to identify areas for improvement and modifications required to enhance their effectiveness for the main study. The modifications made to the instruments based on the pilot evaluation will contribute to the trustworthiness of the collected data, ensuring that the research outcomes accurately reflect the experiences and perspectives of the teacher participants. Overall, by drawing on the lessons learned from the pilot study, the main study will benefit from a more robust and well-informed research process.

Interviews. The interview schedule for the main study was designed to capture information on two primary topics: teachers' strategies and their sources of self-efficacy. The questions regarding teachers' practices yielded rich and detailed responses, successfully identifying needs-supportive practices for student engagement. The participants' input during the pilot interview proved invaluable, as their feedback helped to refine and improve the final interview schedule.

One significant lesson from the pilot interview was participants' initial misunderstanding of the term 'self-efficacy'. To address this, a clear and concise definition of self-efficacy, referring to perceived capability and confidence to achieve specific results, was included in the interview schedule for the main study. This clarification ensured a more accurate and uniform understanding of self-efficacy among both participants.

The pilot interview proved to be a beneficial experience for both the participants and me as a researcher. Participants provided valuable feedback that informed the improvements made to the final interview schedule. They expressed satisfaction with the appropriateness of the questions, and the interviews offered them a platform to share their teaching effectiveness with 'knowledgeable others' (Peng, 2007). The positive experience during the pilot interview played a pivotal role in encouraging both participants to participate in the main study, showcasing the value of conducting a pilot to establish rapport and trust with participants.

For me as a researcher, the pilot interviews provided a valuable opportunity to practice and refine interviewing skills. Care was taken to ensure that participants were given ample time to respond, and I maintained a non-judgmental and non-coercive tone during the interviews.

Questioning techniques were also carefully employed, with follow-up questions based on participants' responses, specific examples requested to enrich understanding and leading questions avoided to maintain the integrity of the data.

Lesson Observations. The use of iPads for video recording proved successful in capturing the classroom interactions during the observed lessons. It became evident, however, that some classroom interactions, particularly individual or small-group conversations between teachers and students, were not fully captured through video recording. Nevertheless, the lesson observation data served its intended purpose by confirming the practices mentioned by teachers in the initial interview. Additionally, the observation data proved valuable in identifying strategies that were overlooked during the initial interview, enhancing the depth of understanding of teachers' practices.

During their final interview, the teachers provided valuable insights and explanations for the newly identified strategies observed in the recorded lessons. Two issues were noted, however. First, covering all the recorded lessons in a single final interview led to information overload, making it challenging for teachers to thoroughly explain each strategy. Second, the time gap of nine weeks between the first recorded lesson and the final interview posed difficulties for teachers in recalling the specific reasons for their implementation of certain strategies.

To address these issues and ensure a more comprehensive and timely exploration of teachers' practices, a post-lesson interview was introduced for the main study. Drawing from the principles of the think-aloud practice (Cotton & Gresty, 2006), following each observation, a post-lesson interview was conducted immediately. This approach allowed teachers not only to reflect on their instructional methods but also to verbalize additional insights, expand on the list of practices observed, and offer rationale for their instructional choices while the details were still fresh. Integrating post-lesson interviews after each observation and aligning with the think-aloud practice significantly enriched the research process. This enrichment facilitated the identification of practices in subsequent lessons and notably enhanced the overall quality of the collected data.

This modification in the research design reflects the reflexive approach taken to improve the methodology based on the lessons learned from the pilot study. By incorporating post-lesson interviews, the main study adopted a more effective and efficient approach to capturing teachers' practices and self-efficacy beliefs in the online teaching environment. This iterative process highlights the commitment to refining the research methodology and ensuring the credibility of the study's findings.

Artefacts. Indeed, the collection of artefacts in conjunction with interviews and lesson observations plays a crucial role in enhancing the depth and credibility of the research findings. The collected artefacts, such as worksheets and other teaching materials, offered valuable supplementary evidence to support teachers' claims and explanations. This complementary approach provides a more comprehensive and nuanced understanding of the phenomena being investigated, ultimately contributing to the trustworthiness of the study's findings. Moreover, the artefacts offered a means of capturing aspects of teachers' practices and beliefs that may not be fully conveyed through interviews and observations alone. They provided context-specific details and insights into the instructional decision-making process, shedding light on the teachers' thought processes and intentions. As such, artefacts as a data-collection strategy were also adopted for the main study.

The Main Study

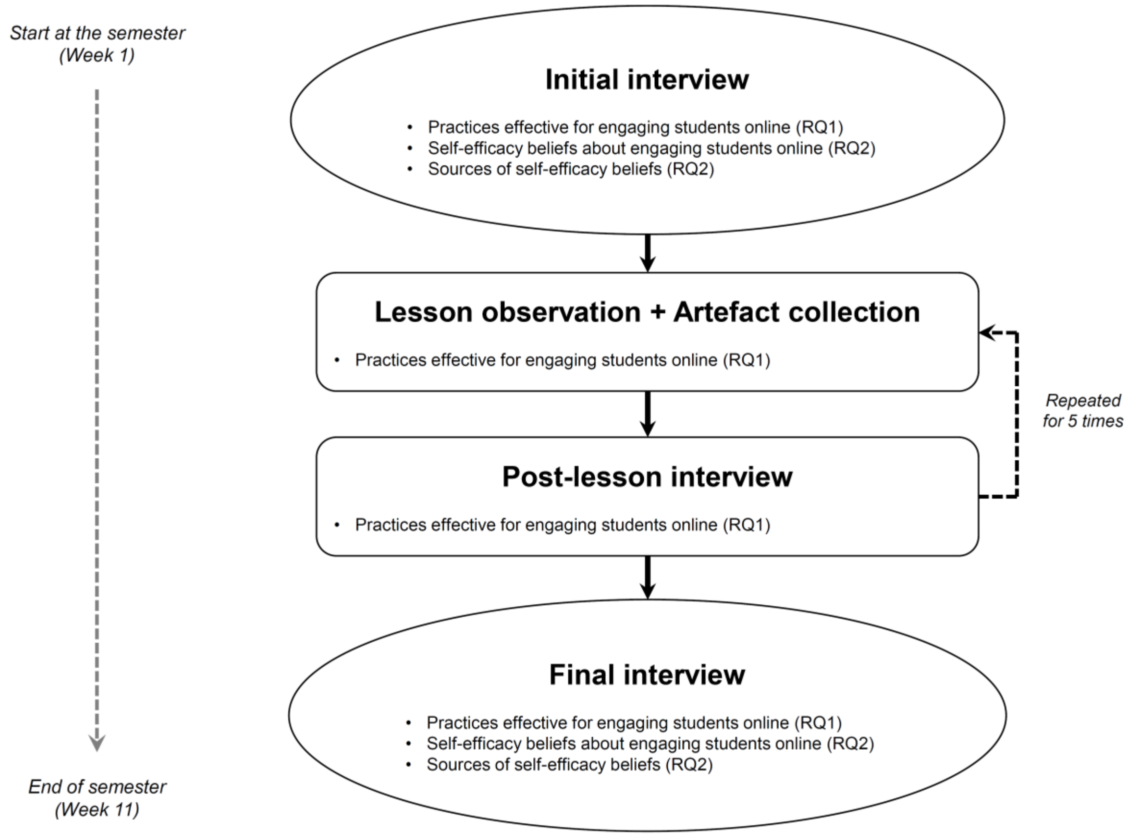
The Process

The main study was conducted during the second semester of ERT, October–December 2020. As a result of the shift to online teaching and the lessons learnt from the pilot study, the data-collection procedure was modified to suit the online teaching context. Due to the limited number of biology teachers available at the College and their alignment with the outlined criteria, the same two teachers who participated in the pilot study were selected and invited to participate in the main study. Their prior familiarity with the research topics, methods and I contributed to a more comfortable and cooperative research environment, reducing participant anxiety (Janghorban et al., 2014). Additionally, having the same participants in the main study streamlined the participant-recruitment process, saving time and effort (Ismail, Kinchin, & Edwards, 2018).

Figure 3.1 presents the data-collection procedure for the main study. Given the lockdown restrictions, the initial interviews were conducted over Zoom and video-recorded. The interview followed a semi-structured format, with questions tailored specifically to the online teaching context (see Appendix 4 for interview questions). Each interview lasted approximately 60 minutes. After the interviews were transcribed and reviewed, I emailed the transcripts to the teachers and prompted them to provide additional thoughts and insights about various aspects of their practices and self-efficacy beliefs.

Figure 3.1

Data-Collection Procedure



The data-collection process for the main study involved each teacher recording five tutorial classes over the course of the semester. Prior to recording each class, the teachers informed the students that the recording would be used for research purposes, and no objections were raised by any student. Students were also given the option to turn off their cameras if they preferred not to be video-recorded. It should also be noted that breakout room activities could not be recorded. The choice of allowing students to turn off camera and the lack of capability to record breakout room activities could impact the dynamics of the online classroom, for example it could influence peer-to-peer/ to-teacher interactions. The recorded lessons ranged from 35 to 50 minutes in duration, and the teachers provided me with links to their videos and related artefacts, including worksheets, screenshots of Canvas pages and samples of student work.

A total of ten video-recorded lessons from the two teachers were received and observed. As soon as each video link was received, the observation of the lesson commenced. During the observation, a pro forma (see Appendix 3) was used, listing practices obtained from the teacher interviews. Following the observation, a post-lesson interview was arranged with the teacher to consider practices, events and student responses that had not been previously discussed. The post-lesson interviews were also conducted via video on Zoom and served to expand the list of practices after each observation, facilitating the identification of recurring practices in subsequent lessons.

The final interview, conducted in a setting similar to the initial one, was recorded over Zoom using a semi-structured format. Teachers were asked specific questions on their perspectives regarding these issues: sustaining concentration, effective collaboration and independent learning and what additional measures they were implementing to support students in these three areas. The interviews also provided an opportunity for participants to revisit their previous discussions on self-efficacy beliefs and offer further information if necessary. Each final interview with a participant lasted approximately 60 minutes.

After the completion of data collection, I expressed gratitude to each participant for their valuable time and effort in the research and offered them the option to review a summary of the study. Both participants chose to review the summary and provided no further comments after reading it. The incorporation of these themes and participants' perspectives enriched the overall understanding of the phenomena under investigation and contributed to the trustworthiness and robustness of the study's findings.

Data Analysis

The data analysis in this study aimed to achieve a comprehensive understanding of the phenomenon under investigation. While lesson observation and artefact data were not subjected to separate analyses, they played a crucial role in complementing the interview data. The observation data and artefacts were used as supporting evidence to contextualise the subjects and gain insights into the teachers' use of these materials in their teaching practices (see Appendix 3). This holistic approach to data analysis enabled a richer and more nuanced interpretation of the research questions (Constas, 1992).

The Process

This study employed Braun and Clarke's (2006) thematic-analysis approach to develop themes from the qualitative data gathered during the research process (see Figure 3.2). The following steps outline the process of thematic analysis:

Step 1: Familiarising Yourself with Your Data and Step 2: Generating Initial Codes. The primary data source was the interview transcripts, which were used to explore the needs-supportive practices of and sources of self-efficacy in teachers. Secondary sources, such as lesson worksheets, Canvas materials and student-related documents, were used to gain a broader understanding of the lesson context and students' interactions with the materials. The interview transcripts were thoroughly read, and relevant areas of interest were annotated, guided by SDT and sources of self-efficacy.

Step 3. Searching for Themes. The coding process involved a selective approach to identify needs-supportive practices and sources of self-efficacy. Codes were reviewed, and some were merged or renamed to improve clarity and accuracy. The codes were then grouped into themes based on their content.

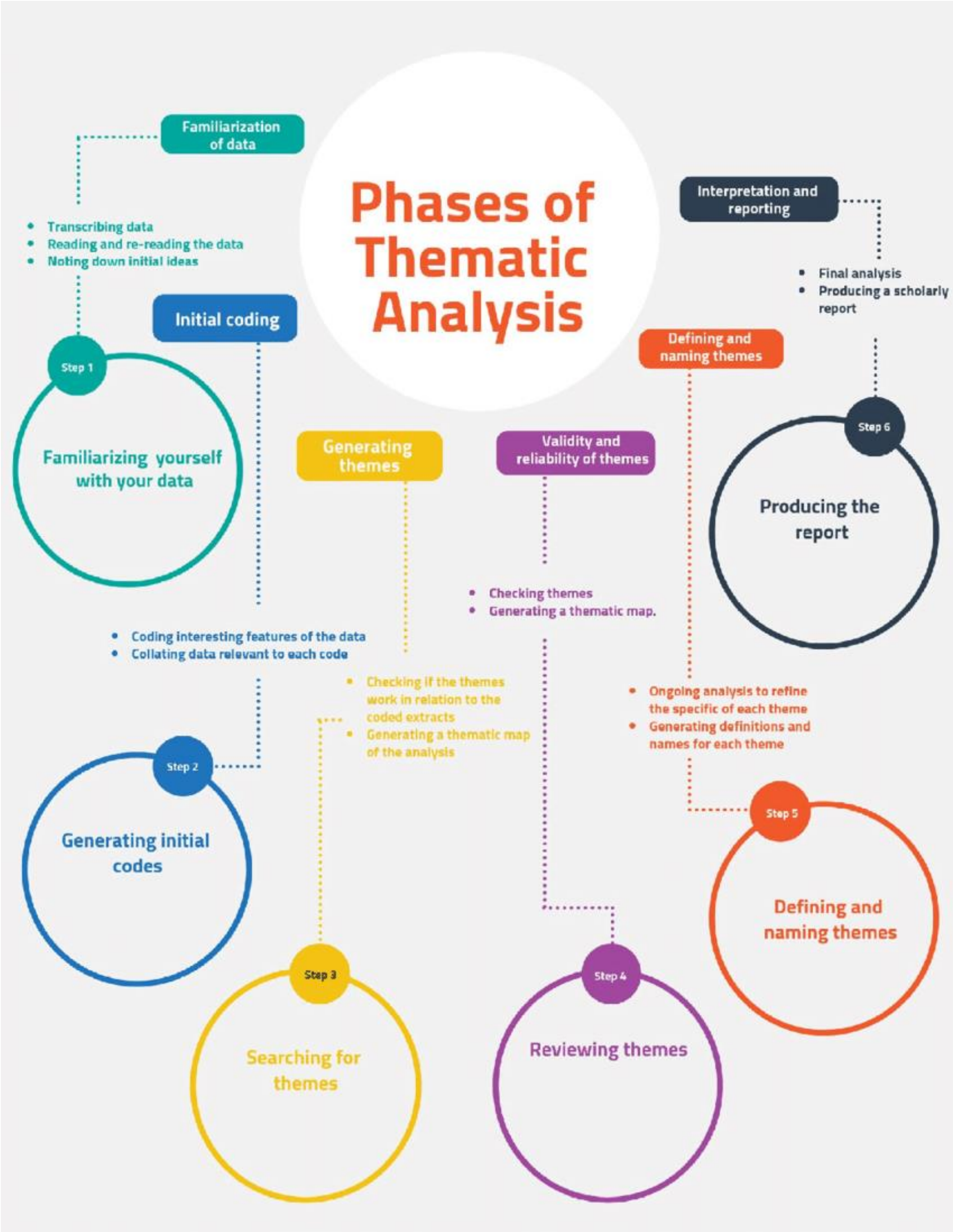


Figure 3.2 *Thematic Analysis Using Braun and Clarke's Approach*

Adapted from *Using thematic analysis in psychology.*, by V. Braun & V. Clarke, 2006, *Qualitative research in psychology*, *3*(2), p. 87.

Step 4: Review of Themes. The identified themes were carefully reviewed to ensure that they accurately reflected the data and addressed the research questions. In this step, some themes might have been merged or renamed to enhance coherence and represent the data more effectively.

Step 5: Defining and Naming Themes. Each theme was refined, and specific definitions and names were generated to clearly convey their content. Similar themes were grouped together to represent the broader categories of SDT and sources of self-efficacy. A thematic map was developed to visualise the relationships between the main themes and sub-themes. Table 3.3a shows a thematic map of the identified needs-supportive strategies used by both teachers during the ERT. This table categorises and delineates the various strategies used to meet the psychological needs of students and promote engagement in the online learning environment. Table 3.3b illustrates a thematic map of the sources of teacher self-efficacy in the context of online teaching. This table categorises the various factors and influences that contribute to teachers' confidence and efficacy in their online instructional practices. In presenting the findings, quotations from the interviews were edited slightly for grammar and punctuation to ensure readability while preserving the essence of the participants' statements. See Appendices 6 and 7 for samples of transcripts as a summary of the findings of the thematic analysis.

Step 6: Producing the Report. The thematic-analysis process was completed in the writing of the results section (Chapter 4) and the discussion of the findings in the context of SDT and sources of self-efficacy theories (Chapter 5). The discussion chapter presented a comprehensive and in-depth exploration of how needs-supportive practices and sources of self-efficacy contributed to engaging students during ERT while reflecting on these findings in light of previous studies discussed in the literature review.

Using artefacts and lesson observation data to support the interview data. I here use Teacher A's strategy of chunking complex concepts into manageable segments (Theme 1.1) to demonstrate the use of artefacts and lesson observations to deepen my understanding of the post-lesson interview. In the interview, Teacher A talked about how she developed small, manageable asynchronous learning activities on Canvas before the online tutorial, followed by carefully designed tutorial activities that give students a sense of success after each chunk of activities to build student understanding.

Teacher A gave me access to the Canvas pages (artefacts; see Appendix 8.1, Theme 1.1), where students received reading materials and a slideshow about the structure and function of lipids. I have also seen that checkpoint questions were interspersed throughout the slideshow to assess students' understanding. I have also read in the online discussion forum on Canvas that Teacher A prompted students to post a response by explaining lipid metabolism concepts in female athletes, and she has provided feedback on the students’ responses.

During the classroom observations, I noticed that Teacher A started by reviewing the triglyceride structure with the students before moving on to a case study on partial dehydrogenation, a more complex concept. Students then participated in a group activity to apply their knowledge of lipid chemistry to real-world scenarios. These observed activities were a clear sign of using a series of small, manageable chunked activities that progressively build students' understanding of complex biological concepts.

By combining interview data with artefacts and lesson observations, I was able to see firsthand how Teacher A effectively chunked complex concepts into manageable segments in both asynchronous and synchronous environments to promote student engagement and interaction in the online learning environment. The artefacts and lesson observations provided valuable insights into the nuances of instructional delivery, student engagement, and the efficacy of strategies in the online learning context, which enriched my analysis and interpretation of the interview data.

Reflexivity

The reflexive nature of the analysis process played a crucial role in maintaining the rigor and trustworthiness of the study. As Tobin and Begley (2004) have highlighted, reflexivity is a primary principle of ‘goodness’ in research, ensuring that I as the researcher remains aware of his or her subjectivity and actively engages in critical reflection throughout the analysis.

Multiple readings of the interview transcripts allowed for the identification and development of both latent and semantic themes. By delving into the underlying and explicit meanings expressed by the participants, the analysis captured the rich descriptions of teacher beliefs and practices from their own perspectives, as advocated by Braun and Clarke (2006).

During the analysis, I constantly reflected on my own assumptions, beliefs, values, educational background and work experience, acknowledging how these factors might have influenced my interpretations. Being mindful of the potential effect of my role as a programme manager within the organisation, I took extra care to prevent any projection of my work role onto the teacher participants, which could have potentially biased the analysis.

The commitment to adopting an emic view—understanding the phenomenon through the eyes of the participants (Beck, 1979)—was a significant aspect of the reflexive approach. By considering the perspectives and experiences of the teachers, the analysis ensured a more comprehensive and unbiased exploration of their beliefs and practices.

Table 3.3a Thematic map – needs-supportive strategies

Online Challenges	Strategy	Definition	Example
Sustaining concentration To help students maintain or improve their concentration when studying the subject.	Chunking and checkpoints (Theme 1.1)	The theme refers to the practice of breaking down information into smaller, manageable 'chunks' and incorporating regular checkpoints to ensure understanding and retention.	"I break down the concept into different sections or subtopics. Once I've identified the main components of the complex concept, I create checkpoint activities for each section. These activities serve as checkpoints or mini-assessments for students to gauge their understanding before moving on to the next part". (Teacher A)
	Deliberate rehearsal of concepts (Theme 1.2)	The theme highlights the importance of actively and intentionally practicing and reviewing concepts to reinforce understanding and promote long-term retention among peers.	"One strategy I use, you know, is to have students work in pairs and explain things to each other. I see that, when they explain to their peers, it really helps them understand better. So I give them a topic or a concept, and then I randomly pair them up. That way, they can learn from each other and really make progress together". (Teacher B)
	Information reorganisation (Theme 1.3)	The theme emphasises the process of reorganising or restructuring information to enhance comprehension and retention in student learning.	"I cannot show them this graph and ask them to read the explanation later on. The concept is complicated. By the time they go to the explanation, they already forget about the changes in the graph". (Teacher A)
	Kinaesthetic activities (Theme 1.4)	The theme focuses on incorporating hands-on activities, such as physical movement and home experiments, to enhance learning.	"I always believed in hands-on activities. They make students get involved and really understand things. So, we had this investigation about osmosis. It's all about how water moves through selectively permeable membranes. I asked students to get some simple things like eggs, salt, vinegar and different sugars to do the investigations. Just things you can find in your kitchen, no problem at all!" (Teacher A)
Effective collaboration To minimise students' reluctance - and enhance their	Online collaborative tool familiarisation (Theme 2.1)	This theme refers to the process of introducing students to and familiarising them with various online collaborative tools.	"When the shift to online learning occurred, I knew that effective communication and collaboration were crucial. I began by having an introductory session to go through the functions of Zoom. I demonstrated to students on how to use different features and navigate the platform effectively. I then set up some tasks for students to practice using Zoom for collaboration". (Teacher A)

Online Challenges	Strategy	Definition	Example
capability - in working collaboratively with peers	Promoting the benefits of collaborative learning (Theme 2.2)	This theme emphasises the importance of highlighting and promoting the advantages of collaborative learning.	”I made activities for students to work together. And after they finished, I gave them time to think back and see what good things they found. They reflected on their experience and noticed the positive stuff. It’s important for them to see what they did well and learn from it”. (Teacher B)
	Resources for a fruitful collaboration (Theme 2.3)	This theme revolves around the provision of resources that facilitate productive and successful collaboration among students.	”Guided questions and hints, oh yes, they are really important, you know? They help students think and bring out different ideas during group work. These resources, like little prompts, they make students look at things from different angles, you know? They encourage them to think outside the box and really dive deep into the topic we’re studying”. (Teacher B)
	Discussion support for effective collaboration (Theme 2.4)	The theme is about teachers’ use of discussion-support tools and techniques like discussion protocols, sentence starters or discussion rubrics to guide students in their discussions.	“I also made use of sentence starters. They are phrases that students can use to initiate their contributions during discussions, for example, I agree with you because . . . or one point I would like to add is . . .”. (Teacher A)
	Same group members throughout the semester (Theme 2.5)	The theme is about teachers’ helping students work together in the same groups or teams consistently over the course of a semester.	“One of big advantage is that students become more comfortable with group members over time, you know? They get to know strengths and weaknesses of each other, learning how to work together better. This familiarity helps with communication and collaboration within group, you know? Like, they can really talk and work together, you know?” (Teacher B)
Independent learning To support students to become autonomous learners	Fostering relevance (Theme 3.1)	The theme refers to teachers’ efforts to make the learning content and activities meaningful and relevant to students’ lives and real-world contexts.	”I believe that when students can see the connection between what they are learning and their own lives, it ignites their curiosity and motivates them to engage deeply in the content”. (Teacher A)
	Offering choices	The theme refers to the practice of providing students with options and	“Some prefer simulations, some enjoy watching a video, some gain

Online Challenges	Strategy	Definition	Example
	(Theme 3.2)	opportunities to make decisions about their learning.	more when they do it, the hands-on". (Teacher B)
	Providing timely feedback (Theme 3.3)	The theme emphasises the importance of offering individualised and timely feedback to students.	"I designed an online quiz that assessed students' understanding of cellular processes. As soon as students completed the quiz, the platform provided detailed feedback, explaining why certain answers were correct or incorrect. This instant feedback allowed students to reflect on their knowledge gaps and revise their understanding. I noticed that students who received immediate feedback were more likely to address their misconceptions promptly and demonstrate improved performance in subsequent assessments". (Teacher A)
	Promoting self-reflective practice (Theme 3.4)	The theme entails encouraging students to engage in self-reflection on their learning process and outcomes.	"One tool I used was confidence checklists, which helped students assess their understanding and confidence in specific learning objectives. Through these checklists, students could identify their strengths and areas for further improvement, allowing them to take charge of their own learning". (Teacher B)

Table 3.3b Thematic map – sources of teacher self-efficacy

Source of Teacher Self-efficacy	Theme	Definition	Example
Mastery Experience a person's first-hand successful experience and performance in a	Motivational strategies before and during the ERT (Theme 4.1)	Firsthand experiences and insights gained by teachers in implementing motivational strategies both before and during ERT	"I had prior success with certain strategies in face-to-face classrooms. So, when transitioning to online teaching, I felt confident that these strategies could be modified and used effectively in the new medium". (Teacher A)

Source of Teacher Self-efficacy	Theme	Definition	Example
task (Bandura,1977)	Designing engaging resources online (Theme 4.2)	The theme focuses on educators' direct experiences in creating compelling and interactive resources for online learning	"During the ERT, you know, I realised that Canvas was more than just a place to store files. It turned into a platform where I could create interesting learning materials and make teaching and learning more effective. It became a tool that really engaged my students and helped me deliver quality education". (Teacher B)
	Monitoring student engagement and achievement online (Theme 4.3)	The theme refers to educators' experiences and insights into effectively monitoring and assessing student engagement and achievement in the online learning environment	"I was fortunate to discover online tools that helped me understand and monitor learner engagement. For instance, using Canvas analytics, I could track how students learned the materials and participated in online tasks like quizzes. I could see the amount of time spent on Canvas and the number of pages viewed in a given week. This experience provided valuable insights into student learning behaviours" (Teacher A)
Vicarious experience a learning experience gained by observing others who have completed a specific task successfully (Bandura,1977)	Contextual elements (Theme 5.1)	The theme emphasises the recognition and consideration of specific contextual factors, such as subjects, teachers and students, that influence the teaching experience.	"Absolutely. I vividly remember observing a colleague who taught Chemistry, similar to my subject. I noticed that their students were making study notes when learning online. Seeing the actual notes created by the students gave me comfort and confidence. Additionally, hearing about the technology glitches they encountered provided me with valuable tips to avoid similar troubles. When someone you already recognise as effective in your eyes demonstrates successful strategies, it naturally boosts your confidence in using those strategies yourself". (Teacher A)
	Exemplars (Theme 5.2)	This theme highlights the role of exemplars in facilitating vicarious experiences for learners.	"When I saw my colleagues using effective strategies, it was really convincing and inspiring for me. Learning from their examples and seeing the good results they got, it gave me the confidence to try similar strategies in my own online teaching. It made me believe that I can do it too!" (Teacher B)

Source of Teacher Self-efficacy	Theme	Definition	Example
Social persuasion the verbal or nonverbal judgement of others on our ability to perform a specific task (Bandura,1977)	Credible members (Theme 6)	The theme refers to the effect of supportive and encouraging words from credible members on a teacher's self-efficacy.	"My two teenage daughters have been invaluable in boosting my self-efficacy as an online teacher. They have become my "guinea pigs" for the online course I'm developing. They provide valuable insights into what works well and what needs improvement. Their opinions matter because they represent the perspective of typical teenagers". (Teacher A)
Emotional states how an individual feels after completing a specific task (Bandura,1977)	Balancing negativity with positivity (Theme 7.1)	The theme refers to the importance of acknowledging and managing negative emotions while actively cultivating positive emotions during ERT.	"It's true that I have fewer interactions with colleagues now, but I have more time to see and talk to my daughters. My bond with them has grown stronger. They have become the guinea pigs for my online course, and their responses and feedback provide me with confidence, certainty and courage in my design. Valuing my mental health and maintaining a positive relationship with my daughters have definitely provided me with the self-efficacy I need to teach online". (Teacher A)
	Enhancing positive emotion: honouring passion (Theme 7.2)	This theme emphasises a deep enthusiasm and dedication that teachers have for their role as educators.	". . . remember why you became a teacher in the first place and let that passion guide you". (Teacher B)
	Enhancing positive emotion: adaptability (Theme 7.2)	This theme refers to a teacher's ability to adjust, modify and respond effectively to the changing demands, challenges and circumstances	"The transition to online teaching has been a transformative journey for me. It has made me more open to innovation and more receptive to change. I've learned to be flexible and adaptable, and it has reinforced the importance of creating a supportive learning

Source of Teacher Self-efficacy	Theme	Definition	Example
		presented by the online learning environment.	environment for my students, regardless of the teaching format". (Teacher A)
	Enhancing positive emotion: Reflection (Theme 7.2)	This theme emphasises the importance of self-reflection and critical evaluation of one's teaching practices.	"I think reflection is really important for personal growth. That's why I keep a notebook where I write down my thoughts and reflect on my teaching. It helps me see any flaws or weaknesses in my materials. I can pinpoint areas that need improvement and make the necessary adjustments. It's a valuable tool for me to become a better teacher". (Teacher B)

Trustworthiness

In qualitative research, the concept of 'trustworthiness' is more relevant than the traditional notions of validity and reliability commonly associated with quantitative research. This is because qualitative research, unlike quantitative analysis, is concerned with uncovering, interpreting and comprehending phenomena in context-specific settings using a naturalistic approach (Guba & Lincoln, 1989). The data supporting the research must be defensible, and the design and methods used must instil confidence and integrity in the pursuit of trustworthiness. In a qualitative study, four factors can influence trustworthiness (Ary et al., 2002; Lincoln & Guba, 1985):

- Credibility (replacing internal validity in quantitative methods) is based on the researchers' representation of the experiences of participants, meaning that explanations of enigmatic situations must be faithful representations (Winter, 2000).
- Transferability (replacing external validity) refers to the extent to which qualitative research findings can be generalised or transferred to better understand other (similar) situations, contexts or settings. Rich and thick descriptions that clearly describe the study's context are, therefore, essential.
- Dependability (in place of reliability): emphasises the need for the researcher to specify the context in which research takes place since most qualitative research cannot be perfectly replicated.
- Confirmability (replacing objectivity) refers to the degree to which the findings can be confirmed or corroborated by multiple sources or others in a similar context because researchers bring a unique perspective to qualitative research.

Minimising the Threats to Trustworthiness

It is acknowledged that threats to trustworthiness can never be eliminated entirely. Instead, by paying attention to the four elements listed above throughout the research process, the negative effects of these threats can be mitigated. The following paragraphs describe how the four elements influenced my actions during the research process to mitigate potential threats to trustworthiness.

Thick Description. Throughout the thesis, I clarified the contexts (e.g., the transition from on-campus to online learning, the challenges of online teaching), theories (i.e., SDT and self-efficacy beliefs) and domains (e.g., university pathway programmes, first-year science subjects, student engagement, online teaching) to allow readers to confidently generalise or transfer findings to similar contexts (Geertz, 1973). I also achieved thick description by engaging in prolonged engagement, triangulation and respondent validation (Creswell, 2014). See below for details.

Prolonged Engagement. A thick description is further contributed by prolonged engagement, where my research spanned an entire semester and provided me with a broad understanding of the context and phenomenon (Henry, 2015).

Triangulation. Findings were corroborated by different data sources. Even when the lesson observation and artefact collection data were not analysed, the fact that they were in addition to interviews could still contribute to triangulation (Patton, 2002). The two sources served to 'validate' teacher practices and self-efficacy beliefs. At the same time, multiple data sources can overcome potential bias, inform my interpretations better and form thick descriptions. For example, when I identified practices or events in the observed lessons that were not mentioned in previous interviews, I discussed them with the teachers in the post-lesson interviews by giving them opportunities to explain and clarify the lesson's context or subject. In this way, I can reduce the possibility of overestimating or underestimating the complexity of particular events during the lessons (Cohen et al., 2017). During both interviews and observations, I took thick, rich descriptive field notes (see Appendix 3) and collected artefacts, which helped me notice more and made me conscious of what I noticed.

Respondent validation. The respondent validation involved sharing the interpretive process and results with my participants through the distribution of transcripts and a summary of the findings. I also encouraged participants to provide further comments that could shed new light on the data, enriching the detailed and thick descriptions of the study.

Audit Trail. I maintained a comprehensive audit trail throughout the data-analysis process. Verbatim transcriptions of interview recordings were created to ensure accurate records of participants' responses. I also documented how main themes and subthemes were identified and developed, and I regularly referred back to these notes to verify the appropriateness of my coding decisions. These actions are in line with established best practices for qualitative research and help ensure the trustworthiness of the data sources and analysis (Gerring, 2007; Golafshani, 2003).

Reflexivity. As mentioned in the 'Research Design' and 'Pilot Study' sections, throughout the research process, I engaged in reflexivity to acknowledge and examine my own biases, assumptions and positionalities that may have influenced the study. During data collection, I reflected on how my previous experiences and education might affect my interactions with participants and shape my interpretations of their responses. As I conducted the data analysis, I was aware of my own subjectivity and actively challenged my assumptions by considering alternative perspectives and interpretations. I frequently revisited my research questions and re-evaluated my methods to ensure they aligned with the participants' perspectives and experiences. Additionally, I made notes on my own thoughts and feelings throughout the process to further reflect on my own role in the research. Through these reflexive practices, I aimed to increase the trustworthiness of the study.

Ethical Considerations

This study adhered to the ethical guidelines set out by the British Educational Research Association's (BERA) Ethical Guidelines (BERA, 2018; see Appendix 5.1). Throughout the research process, ethical concerns were discussed with my doctoral supervisors. When the research context changed from face-to-face tutorials to online teaching in 2020, a minor amendment was approved (see Appendix 5.2). This section describes how ethical concerns were addressed to ensure that all participants were treated with respect and dignity and that their confidentiality was maintained (BERA, 2018).

Participant Recruitment

Participants were chosen based on the criteria outlined earlier, regardless of gender, race, professional experience, or institute status.

Informed Consent

Before the research commenced, consent from the Dean of Studies at the research site was sought (Appendices 1.2 and 2.2). The purpose and procedures of the study were then explained to each teacher participant before the initial interview, and any questions they had were answered. Participants openly discussed the risks and benefits of participation. Participants were given the information sheet (see Appendix 1.1) and explained the purpose of the research and the procedures involved during the initial meeting before they decided to participate (or declined to). It was explained that SDT and self-efficacy beliefs would be the theoretical lenses through which they would examine their teaching practices and self-efficacy beliefs for engaging students in online learning. The potential benefits of their participation, such as improving student engagement in online learning, and the fact that professional dialogues with outside experts can help teachers reflect on their work and increase job satisfaction (Peng, 2007), were also discussed. It was made clear, however, that participation was voluntary and that they were under no obligation to participate. Both participants agreed to take part and signed the consent form (see Appendix 2.1).

Data Collection

To ensure confidentiality, interviews were conducted in a private, vacant classroom at the institute in the pilot study and in private Zoom meetings in the main study. Participants were informed that the beliefs and practices revealed during the interviews and observations would be used solely for research purposes and would have no effect on their professional standing. They were also reminded that they could refuse to answer any question without being asked why. Participants could withdraw from the study at any time before 31 October 2019 for the pilot study and 31 December 2020 for the main study, and all their data would be deleted if they did so. During the interviews, there were no observed sign of discomfort or uneasiness shown by the participants.

Students were contacted via email and given the necessary information to consent to the video recording of tutorials (see Appendices 1.3 and 2.3). Those who did not consent were not filmed in the pilot study, and they could opt out of the main study by turning off their cameras in Zoom. The ethics committee deemed these considerations reasonable because this study posed little risk and may benefit students' learning.

Confidentiality and Anonymity

Following BERA guidelines, individual identities and identification factors were not disclosed during data collection, analysis, reporting and dissemination. To identify participants, a name list with first names linked to unique identifiers was kept. This sheet was password-protected and remained with me. No other people had direct access to these data, including personal information, because I prepared all transcripts and other study-related materials. If significant excerpts from interviews were quoted, the quotation and commentary were double-checked with the teacher participants involved. To protect participants' privacy and anonymity, all names were changed, and any identifying information was removed from the data. All data were collected and securely stored in password-protected files on the UCL N-Drive to maintain confidentiality.

Chapter 4: Results

Chapter 1 highlighted the pressing issue of attrition among science students at UTS College and its significant consequences for individuals and society as a whole. The high attrition rates observed in the Diploma of Science programme, both at the research site and other pathway providers in Australia, necessitated an in-depth investigation into this phenomenon. The abrupt emergence of the COVID-19 pandemic brought about unprecedented circumstances that compelled HE institutions, including UTS College, to swiftly transition to ERT and support students in online learning environments. With the goal of mitigating attrition, my research on understanding how science teachers at UTS College supported pathway student engagement shifted from face-to-face tutorials to online—both the synchronous and asynchronous environment. Specifically, I examined how teachers employed needs-supportive strategies to help students overcome the challenges of online learning, including sustaining concentration, facilitating effective collaboration and fostering independent study (research question 1). To understand how science pathway teachers, who had no prior experience with online teaching, developed capability and competence in online teaching, I explored the teachers' development of self-efficacy in the ERT context (research question 2).

This chapter presents the results obtained through a comprehensive exploration of these research questions. By shedding light on the strategies employed by science teachers and their development of self-efficacy in the online learning environment, the findings provide valuable insights to support teachers in designing and delivering effective online teaching. Ultimately, these insights should help alleviate the issue of disengagement and the high attrition rate in science programmes.

Needs-Supportive Motivational Strategies Used by Teachers

The foundation of this study is Deci and Ryan's SDT (Deci & Ryan, 2010), a well-established framework emphasising the significance of supporting students in fulfilling their psychological needs for competence, relatedness and autonomy. This study has identified 13 needs-supportive strategies identified in this study, and all strategies were implemented by both Teachers A and B. Table 4.1 provides the strategies, categorises the types of needs they aim to satisfy (based on SDT) and indicates whether they were adapted and modified from the pre-ERT era or newly developed during ERT.

The table shows that, of 13 strategies, four were dedicated to sustaining concentration, five to promoting collaborative learning and four to encouraging students to learn independently. Based on SDT, 11 of 13 belong to competence- and autonomy-supportive strategies, and only six belong to relatedness-supportive strategies. Based on teacher participants' accounts, it was found that nine of the 13 strategies were previously employed successfully in face-to-face teaching before the ERT era. To adapt these strategies seamlessly into the online realm, modifications were made to suit the unique requirements of remote learning. This discovery highlights the critical role of teachers' mastery experiences, first-hand successful experience, in using effective needs-supportive strategies in the pre-ERT and ERT eras, which ultimately contribute to creating engaging online learning experiences for students. (Further details will be discussed in the 'Development of Teacher Self-Efficacy Beliefs in Online Teaching' section.)

The following section discusses each strategy and how each addresses the challenges of online learning by catering to students' psychological needs as provided by the two teachers during ERT.

Table 4.1 Needs-supportive motivational strategies found in this study

Strategy	Needs-supportive category			Online activity		Implementation	
	Competence	Relatedness	Autonomy	Asynchronous	Synchronous	Pre ERT	During ERT
Theme 1: Addressing sustaining concentration							
Chunking and checkpoints (Theme 1.1)	✓		✓	✓		✓	✓
Deliberate rehearsal of concepts (Theme 1.2)	✓	✓	✓		✓	✓	✓
Information reorganisation (Theme 1.3)	✓			✓			✓
Kinaesthetic activities (Theme 1.4)	✓			✓	✓		✓
Theme 2: Addressing effective collaboration							
Online collaborative tool familiarisation (Theme 2.1)	✓	✓	✓		✓		✓
Promoting the benefits of collaborative learning (Theme 2.2)	✓	✓	✓		✓	✓	✓
Resources for a fruitful collaboration (Theme 2.3)	✓		✓		✓	✓	✓
Discussion support for effective collaboration (Theme 2.4)	✓	✓	✓		✓	✓	✓

Strategy	Needs-supportive category			Online activity		Implementation	
	Competence	Relatedness	Autonomy	Asynchronous	Synchronous	Pre ERT	During ERT
Same group members throughout the semester (Theme 2.5)		✓	✓	✓	✓	✓	✓
Theme 3: Addressing the independent learning							
Fostering relevance (Theme 3.1)			✓	✓	✓	✓	✓
Offering choices (Theme 3.2)	✓	✓	✓	✓			✓
Providing timely feedback (Theme 3.3)	✓		✓	✓		✓	✓
Promoting self-reflective practice (Theme 3.4)	✓		✓		✓	✓	

Theme 1: Needs-Supportive Motivating Strategies that Address Sustaining Concentration

In the realm of online teaching, one key challenge faced by teachers is the ability to sustain students' concentration during the learning process. Within this Theme, four subthemes have emerged as strategies: chunking and checkpoints (Theme 1.1), deliberate rehearsal of concepts (Theme 1.2), information reorganisation (Theme 1.3) and kinaesthetic activities (Theme 1.4). Each subtheme begins with a definition, then evidence, and finally an explanation of how each supports learners in sustaining concentration in a needs-supportive manner.

Theme 1.1: Chunking and Checkpoints. The theme refers to breaking down information into smaller, manageable 'chunks' and incorporating regular checkpoints to ensure understanding and retention.

Evidence. The strategy had been applied before ERT and was modified during ERT for online learning. It is a common practice for teachers to separate complex concepts into manageable chunks. In the pre-ERT era, teachers usually designed a series of activities to achieve a learning outcome during the tutorials, each focusing on a small concept and linking all concepts at the end. Chunking in a physical classroom is usually accompanied by lesson notes and worksheets. In a physical classroom, the teacher may prepare lesson notes that outline the main points or key concepts to be covered in each chunk. These notes can serve as a guide for both the teacher and the students, ensuring that the content is presented in a structured and organised manner. Additionally, accompanying worksheets or handouts may be provided to students to align with the chunked content and provide opportunities to practise and reinforce their understanding of the material.

Both teachers in this study recognised that chunking could also be done effectively on Canvas even before ERT. Before ERT, teachers had already built some pages on Canvas to unpack a difficult concept (Appendix 8.1). During ERT, they continued to build more asynchronous learning activities to support students' mastery of complex concepts online. These Canvas pages house learning activities that were manageable and achievable for students to complete before attending the tutorials. These resources include videos, readings, mini-presentations, simulations and interactive quizzes. Each can be completed within 10–15 minutes.

When teacher A introduced the biochemistry of lipids, she designed two pre-tutorial learning activities that required students to understand the basic structure and function of lipids (Appendix 8.1): reading the extract from the textbook on lipids, and a slideshow discussing the various types and properties of lipids. Checkpoint questions were asked between the slides to test students' understanding or further stimulate their thinking about the concept. In the discussion forum, she tested students' explanatory and logical-thinking abilities by asking them to explain why a low-fat diet can cause amenorrhea in some female athletes. She reviewed and provided students with feedback for their responses on the forum. In the tutorial, she began by reviewing the structure of a triglyceride with her students. After that, students work on a case study of partial dehydrogenation to learn about a more complicated concept: hydrogenation. Finally, students participated in a group activity to help them make an informed decision about the healthiest cooking oil for people with different health conditions.

Teacher B also had a similar strategy:

> *I break down the concept into different sections or subtopics. Once I've identified the main components of the complex concept, I create checkpoint activities for each section. These activities serve as checkpoints or mini-assessments for students to gauge their understanding before moving on to the next part.*

Teacher B unpacked the concept of eukaryotic evolution by providing an evolution tree diagram, followed by a video explaining the endosymbiosis theory on a Canvas page (Appendix 8.1). Next, students demonstrated their comprehension by answering the interactive quiz questions. These chunked learning activities collectively provided students with an overview of the phylogenetic tree within the domain *Eukarya* and developed their understanding of the theory behind evolution. During the tutorials, students collaborated to propose arguments for and against the endosymbiotic theory by comparing the cellular structures of prokaryotic and eukaryotic cells. Students used appropriate examples to apply what they had learned from the pre-tutorial activities to their reasoning.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? By breaking down complex concepts into manageable 'chunks', this strategy addresses the issue of sustaining concentration and promotes students' competence and autonomy development, as the SDT depicts. First, stimulating materials within the chunks "cater to students with varying learning styles" (Teacher A), promoting their autonomy. Teacher A noted that the diverse materials aim to engage and stimulate students' learning processes, allowing them to choose the resources that best suit their preferences and needs.

Second, the manageable size of the chunks helps maintain students' attention and motivation. "Hopefully, when their concentration drops, they enter a new page and get something new to stimulate them", Teacher B said. By limiting video clip lengths to no more than 10 minutes, both teachers recognised the limited focus capacity of students. "Students have a limited ability to focus on a specific topic", Teacher A elaborated. Providing content in smaller chunks allows students some level of control and choice. They can navigate through these segments, allowing for a more self-paced learning experience. Teacher B agreed: "These are not Netflix videos. Because they are content-heavy, a short video can keep their attention span".

Third, their competence gradually improves as students work through the concept pages. According to Teacher B, "Students always want to get all the interactive quiz questions correct, which motivates them to understand the concept fully". This progress in competence not only supports their mastery of the material but also enhances their sense of autonomy and self-efficacy.

Finally, the asynchronous pre-learning concept pages play a crucial role in fostering competence and supporting concentration during synchronous tutorials. "[The pre-tutorial activities] prevent students from processing a lot of new information at the time of the tutorial" (Teacher A). These activities allow students to build a solid foundation of understanding before encountering complex concepts in the tutorials. By reducing the cognitive load during tutorials, students were therefore "less likely to give up when they encountered the complex concepts in the tutorials" (Teacher B), fostering a sense of competence and promoting sustained concentration.

In summary, the strategy of chunking complex concepts aligns with the principles of SDT by promoting students' competence and autonomy. By providing stimulating materials, manageable chunks, opportunities for competence development and pre-learning activities, this strategy supports sustained concentration and enhances students' online learning experience.

Theme 1.2: Deliberate Rehearsal of Concepts. The theme emphasises the importance of actively practising and reviewing concepts to reinforce understanding and promote long-term retention among peers.

***Evidence*.** The strategy was often used in tutorials near the end of a topic's learning (Appendix 8.1). In pre-ERT, students would be given the opportunity in the physical classroom to explain complicated biological processes to their classmates. This method was adapted to the breakout rooms in Zoom during ERT. Teacher A used this strategy when teaching students about complex processes, including aerobic respiration, DNA replication, gene expression, meiotic cell division and dihybrid inheritance. Teacher A said:

> *One strategy I use, you know, is to have students work in pairs and explain things to each other. I see that when they explain to their peers, it really helps them understand better. So, I give them a topic or a concept, and then I pair them up. That way, they can learn from each other and really make progress together.*

Students worked in pairs in the breakout rooms to 'teach' the concept to one another using the diagram (Appendix 8.1) from the tutorial note. Teacher A visited various breakout rooms to ensure students were on task and helped as needed. Following the exercise, one group was chosen at random to give a whole-class presentation (Appendix 8.1). Students were then asked to comment on the accuracy and sufficiency of the concepts. Teacher B used a similar strategy when teaching complex processes, including the alternation of generations, blood glucose regulation, the sliding filament theory of muscle contraction, cardiodynamics, osmoregulation and nerve impulse transmission.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? The strategy of deliberate rehearsal of concepts not only addresses concentration issues related to complex biological concepts and distractions during online learning but also aligns with the theoretical framework of SDT, which emphasises the need for competence, autonomy and relatedness in promoting intrinsic motivation and engagement. When students explain concepts to their peers, they are actively involved in the learning process, requiring them to maintain focus and clarify their own logic and thoughts. This aligns with the need for competence as students strive to articulate their understanding accurately and effectively. Teacher A explained, "before the mini-presentation, the students re-read all the notes again", which further enhances their competence by refreshing their knowledge and ensuring that they are well prepared to explain the concepts.

Moreover, the interaction among students during the explanations creates a sense of relatedness. As peers listen to the explanations, they gain additional information that stimulates their own thinking and provides opportunities for discussion and reflection. "When other classmates listened to the explanation, they got more information to stimulate their brains", said Teacher B, and they can use what they learned to judge the accuracy of the explanation and provide constructive feedback. Teacher B, however, pinpointed that some students may be hesitant to provide feedback to their peers who they believe are more knowledgeable or skilled. Some students may be hesitant to provide constructive criticism to their peers for fear of hurting their feelings or causing conflict in the classroom. Overall, the sense of relatedness created contributes to students' motivation and engagement in the learning process, enhancing their concentration and understanding of the material.

Theme 1.3: Information Reorganisation. The theme emphasises the process of reorganising or restructuring information to improve student comprehension and retention.

Evidence. Both teachers paid attention to the information presented on the online learning materials. The example from Teacher B demonstrated how she integrated information to reduce the splitting of attention, while the example from Teacher A demonstrated how she left out non-essential components to reduce redundancy.

When Teacher B explained the process of nerve impulse transmission, the graphs and textual explanations in the handout were separated (Appendix 8.1). In the on-campus class, students could arrange the graph on the left and the explanation on the right. This is not possible in an online environment. "I cannot show them this graph and ask them to read the explanation later on. The concept is complicated. By the time they go to the explanation, they already forget about the changes in the graph", she said. Students lose focus due to the spatial and temporal separation, making comprehension difficult. As a result, she annotated the graph. The changes and explanations for the events are now kept together on the graph. This modification effectively eliminated the split of attention (Appendix 8.1).

Teacher A also reorganised the information in her learning materials. She discovered that the two pieces of information—the text and the diagrams—introduced the same concepts to students when explaining transportation across the membrane. Rather than removing either, she labelled the text 'for your reference only'. Students first went through the diagram, and, if they were unsure or had additional questions, they could refer to the description in the text box. She believed that "when it is online, the instructions and information must be much simpler and clearer because students cannot get immediate help as easily as they could in the face-to-face [on-campus] environment".

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? Reorganising information in learning materials can be connected to SDT, specifically in terms of promoting students' competence. This strategy sustains students' concentration in two important ways. First, reorganising information eliminates the division of students' attention by space and time. Teacher B highlighted that "the all-in-one annotated diagrams help students focus on the process, and they are less likely to be distracted". This aligns with the need for competence in SDT, as it allows students to dedicate more energy to understanding the concepts, enhancing their sense of competence in the subject matter.

Second, providing clear instructions on required and optional information helps save students' time and reduces redundancy. Elimination of redundant materials, according to Teacher A, could "help solve the boredom issue and sharpen students' focus on learning the concepts". Instead of spending energy on redundant materials, students should direct their energy to develop their competence.

Theme 1.4: Kinaesthetic Activities. The theme focuses on incorporating hands-on activities, such as physical movement and home experiments, during learning.

Evidence. Knowing that students spend long periods in front of computers for online learning, both teachers included kinaesthetic activities during ERT to help students focus while learning. Where possible, Teacher B gave students hands-on experience. One lesson, for example, was designed to help students understand how different joints enable and disable body movements (Appendix 8.1). During the tutorials, Teacher B instructed students to stand in an anatomical position (i.e., erect with feet together, hands at the sides, with the palms facing forward) in front of the computer, away from the camera. She then instructed the students to follow her lead. Following that, each student was required to perform one movement, then invite their peers to describe the movement and the joints involved. She also asked students to move their teeth to demonstrate the importance of non-movable joints in holding teeth in place. Another time, she asked students to create a simple physical model demonstrating how pollen and seeds are structurally adapted for dispersal. Students then presented their models to their classmates (Appendix 8.1).

On the other hand, Teacher A gave students a kinaesthetic experience by conducting home experiments (Appendix 8.1):

> *I always believed in hands-on activities. They make students get involved and really understand things. So, we had this investigation about osmosis. It's all about how water moves through selectively permeable membranes. I asked students to get some simple things like eggs, salt, vinegar and different sugars to do the investigations. Just things you can find in your kitchen, no problem at all!*

All the materials needed are readily available at the supermarket, and the experiments can be carried out safely at home. The teacher compiled a list of questions about the tasks to which the students could respond in the discussion forum. Students also posted their experimental setup with videos and selfies in the discussion forum, providing evidence of their first-hand experience for the teacher. Other home experiments designed by Teacher A include protein denaturation in egg white, extracting DNA from strawberries and enzyme denaturation to prevent apple browning.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? Incorporating kinaesthetic activities, which are consistent with SDT principles, has a positive effect on maintaining concentration in online learning. These activities contribute to students' competence development through two key factors. First, evidence showed that the enjoyment derived from engaging in kinaesthetic activities helps students maintain focus on their studies. Teacher B initially had concerns about student interest, but those worries quickly dissipated when her students eagerly followed her lead in performing body movements during the tutorial. The kinaesthetic elements injected a sense of fun and excitement into what would otherwise be considered monotonous tutorials. The kinaesthetic elements “added so much fun to the boring tutorials where you [students] only sit down most of the time” (Teacher B). This enjoyment factor aligns with SDT’s emphasis on intrinsic motivation, as students’ active participation in these activities fosters a sense of autonomy and competence, ultimately enhancing their concentration and engagement.

In light of the student feedback surveys, Teacher A’s students expressed a high regard for the incorporation of home experiments as kinaesthetic activities, with a substantial number of students considering these activities to be the highlights of the subject. The opportunity to conduct experiments in their own kitchens, involving their family members, brought joy and fun to the online learning experience. Notably, even quieter students became more involved in these hands-on activities. This observation reminded her that “you just need to use different strategies to keep different students out of boredom in learning” (Teacher A). This observation aligns with SDT’s focus on relatedness, as the interactive nature of the experiments promoted social connections and a sense of belonging within the learning environment. By employing diverse strategies to alleviate boredom, Teacher A recognised the importance of catering to individual differences and needs, further supporting the psychological needs outlined in SDT.

Moreover, these kinaesthetic activities facilitated students’ competence in learning the concepts. Teacher B emphasised that actively engaging in body movements and model-making enhanced students’ ability to remember and understand the subject matter. This notion aligns with SDT’s emphasis on competence, as hands-on activities provide students with a tangible and experiential way to comprehend and apply the learned material. Additionally, Teacher A noted that the home experiments helped students grasp biological principles through everyday scenarios, reinforcing their understanding of concepts and further promoting their competence.

In summary, incorporating kinaesthetic activities in online learning supports students' sustained concentration and aligns with the principles of SDT. The enjoyment factor, the promotion of competence and the facilitation of relatedness through hands-on experiences contribute to student's engagement, motivation and competence development within the learning process.

Theme 2: Needs-Supportive Motivating Strategies that Address Effective Collaboration

Effective collaboration is equally as important as sustaining concentration for students' successful online learning experience. Building upon the significance of collaboration, Theme 2 illustrates various strategies for optimising and supporting student collaboration in the context of online learning. The theme comprises five subthemes, each shedding light on essential aspects of fostering effective collaboration in a needs-supportive manner: online collaborative tool familiarisation (Theme 2.1), promoting the benefits of collaborative learning (Theme 2.2), provision of resources for fruitful collaboration (Theme 2.3), facilitating discussion support for effective collaboration (Theme 2.4) and maintaining consistent group members throughout the semester (Theme 2.5). Thoroughly examining the meanings and evidence of these subthemes uncovers valuable insights into how these needs-supportive strategies encourage and optimise collaborative learning experiences, further enriching our understanding of effective online teaching.

Theme 2.1 Familiarising Students with the Online Collaborative Tools. This theme is about introducing and acquainting students with various online collaborative tools.

Evidence. This strategy was put in place at the start of ERT. It aimed to address students' digital competence issues caused by a lack of knowledge of an online technology tool: Zoom. Despite the widespread use of Zoom in online tutorials, Teacher A discovered that some students were "not familiar with these [Zoom] functions even though they have been online in other classes". These essential functions include displaying emojis, typing messages in the chat box, sharing screens, annotating comments on the shared screen and independently joining breakout rooms.

Teacher A explained, "[those functions] help students to express their ideas" because the explanations rely not only on the verbal but also on "the visual through emojis, messages and annotations on the shared screen". Teacher B shared a similar view:

> *When the shift to online learning occurred, I knew that effective communication and collaboration were crucial. I began by having an introductory session to go through the functions of Zoom. I demonstrated to students on how to use different features and navigate the platform effectively. I then set up some tasks for students to practice using Zoom for collaboration.*

She also emphasised that the chat box and emoji are especially helpful "when someone is presenting his or her idea and you do not want to say something to interrupt their presentation". Teacher B stated that some students "don't even understand what annotate means, so they never know they can annotate on the shared screen". So, at the start of the semester, both teachers spent time with students experimenting with these Zoom features.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? Both teachers were pleased to witness the positive effect of the students' improved technological competence for collaboration after the Zoom training session. According to SDT, this strategy is crucial in fostering students' autonomy, relatedness and competence, all three fundamental psychological needs. Teacher A emphasised the transformative effect of mastering the essential functions of Zoom, stating that "it only takes 10 minutes to go through these basic functions, but the effect is powerful when your students master the functions of these tools". This sense of competence not only enhanced their technological skills but also empowered them to express their reactions and responses using emojis and messages, fostering a greater sense of autonomy in their communication and relatedness with their peers during online interactions.

Moreover, in breakout rooms, the norm of sharing screens and annotating diagrams emerged, further reinforcing their competence in using the collaborative features of Zoom. Teacher B highlighted the importance of practice and familiarity in building competence, suggesting that "the more they use, the more familiar they become". This process aligns with SDT, as repeated practice and mastery contribute to a sense of competence and self-efficacy.

Both teachers recognised the relevance of online platforms in the future of work and study. They acknowledged that competence in using the essential collaborative features of Zoom serves as a crucial first step towards students' future success. This connection to the broader context of work and study highlights the importance of technological competence. It aligns with the notion of self-determined motivation, where individuals are intrinsically motivated to develop the skills necessary for their future endeavours.

In summary, the development of students' technological competence through Zoom training aligns with the principles of SDT, as it supports their autonomy, competence and sense of relatedness and sets the stage for their future success in both work and study.

Theme 2.2: Promoting the Benefits of Collaborative Learning. This theme highlights the significance of emphasising and promoting the benefits of collaborative learning.

Evidence. This strategy existed prior to ERT and aimed to increase student participation in collaborative activities. Both believed that 'direct telling by the teacher' might be ineffective at conveying the message to students. "They may not listen to you or just forget about it quickly", Teacher A explained. Teacher B added, "Not only do you need to tell them about the benefits, but also let the learners realise the benefits themselves". Both teachers used reflection to help students understand the benefits of collaborative learning so that they could "truly appreciate the benefits", as Teacher B put it.

The reflection task came after the collaborative activity. After students worked collaboratively on a problem-solving question, Teacher A asked them to brainstorm the reasons for the collaboration. Students posted their ideas in the chat box, and she went through each one, inviting students to elaborate on why they were beneficial to their learning. Teacher B assigned her students to work in groups of three to compare the nature and functions of the skeletal systems of an earthworm, a grasshopper and a human (Appendix 8.1). Because the activity required students to draw on knowledge from multiple modules (the phylum *Annelida*, the phylum *Arthropoda* and the phylum *Chordata*), it was an excellent opportunity for different students to "provide different contributions" and for "students [to] learn something from each other". A task at the end of the worksheet required students to reflect on concepts they had not previously mastered and what they had learned from one another through collaborative activities (Appendix 8.1). Teacher B said:

> *I made activities for students to work together. And after they finished, I gave them time to think back and see what good things they found. They reflected on their experience and noticed the positive stuff. It's important for them to see what they did well and learn from it.*

Students were chosen at random to present their ideas to the entire class. Teacher B also used similar reflective exercises in other tutorials.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? Promoting the benefits of collaborative learning can be strongly linked to the theoretical framework of SDT. Both teachers recognised the importance of students' understanding of the benefits of collaboration in motivating their participation. According to SDT, autonomy is a fundamental psychological need, and, when individuals perceive the value and benefits of an activity, they are more likely to engage in it willingly. Teacher A's belief that students must first "understand why" suggests the importance of supporting students' autonomy by providing them with a rationale for collaborative learning.

The reflective exercise that both teachers used is also consistent with the SDT concept of competence. Teacher A believed the reflective activity helped the students "realise the collaboration activity is actually good for them and their learning". She claimed that "students [had been] more willing to turn their cameras on and chat more in the breakout room" since then. This supports the idea that, when individuals perceive competence and growth in an activity, their motivation and engagement increase. Teacher A's observation that students were more willing to turn on their cameras and participate actively in the breakout room afterward demonstrates the connection between fostering competence through reflection and increased engagement.

Moreover, the reflective activity also relates to the need for relatedness in SDT. By allowing students to share their ideas and learn from each other, the teachers created a sense of belonging and connectedness within the collaborative learning environment. Teacher B's excitement about students' recognising what they had learned from each other indicates the development of positive social interactions and relatedness among students.

In summary, the teachers' belief in the motivating power of understanding the benefits of collaboration aligns with the autonomy aspect of SDT. By assisting students in recognising the advantages of collaboration, both teachers' reflective activity addresses the competence need. Furthermore, the reflective activity fosters relatedness by promoting social connections and the sharing of ideas among students. By incorporating these elements of SDT, the teachers effectively created an environment that supported students' motivation, engagement and overall satisfaction with collaborative learning.

Theme 2.3 Resources for a Fruitful Collaboration. This theme revolves around the provision of resources that promote productive and successful student collaboration.

Evidence. This strategy aims to make students more competent with their subject knowledge. The resources in this strategy refer to cognitive inputs, such as video clips, descriptions of scenarios, sub-questions, hints and adequate time for students to think about the issues or topics in question. Both teachers provided sufficient resources for their students to collaborate. Teacher B asked the students to explain how desiccation affects seed plants and mammals living in the terrestrial environment and how they have evolved to deal with this issue. Teacher B provided guided questions, diagrams and hints to help students unpack the main problem and stimulate their thinking (Appendix 8.2). Teacher B also gave students a pro forma to use in recording and reporting the outcome of the discussion (Appendix 8.2). In terms of time, she gave students preparation time, such as three minutes before the discussion began, to think about their responses. The entire group activity lasted 20 minutes. Teacher A offered a similar set of resources as Teacher B.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? The strategy to provide resources for a fruitful collaboration can be analysed through the lens of SDT, which emphasises the importance of supporting students' competence and autonomy to enhance their motivation and engagement in learning. Teachers recognise that this strategy of providing various cognitive inputs can contribute to students' competence in two ways. First, by offering guiding questions and hints, teachers help students unpack the issue and focus on relevant areas for meaningful discussion. Teacher B said:

> *Guided questions and hints, oh yes, they are really important. They help students think and bring out different ideas during group work. These resources, like little prompts, they make students look at things from different angles, you know? They encourage them to think outside the box and really dive deep into the topic we're studying.*

This support aligns with SDT's emphasis on competence, as it assists students in accurately selecting the correct information and broadening the depth of their thinking. The guiding question example that Teacher B provided demonstrates the significance of drawing students' attention to particular ideas, such as gymnosperms and angiosperms, in the context of seed plants. By clarifying the scope of the discussion, students can avoid unnecessary information overload and engage in more focused and comprehensive discussions. Similarly, the use of diagrams and sub-questions ensures that students consider all relevant aspects and contribute to a more thorough exploration of the topic.

These cognitive resources not only enhance students' competence but also promote their autonomy by allowing each student to contribute to collaborative activities. Teacher B believed '*there is at least one sub-question you* [students] *can respond to and you can contribute to*'. By providing sub-questions that cater to different levels of understanding, teachers empower students to actively participate and share their unique perspectives. This aligns with SDT's focus on autonomy, as students are given the freedom to engage with the material in a way that suits their abilities and interests.

Second, the allocation of more time for both preparation and actual collaborative activities is critical for achieving fruitful outcomes. This aspect relates to SDT's emphasis on autonomy and competence. Allowing students sufficient time for preparation enables them to gather their thoughts, consider different perspectives and formulate meaningful contributions. The preparation time may benefit "students whose English foundation and discussion skills are weak" (Teacher A), as it supports their competence development and increases their participation. Moreover, the teachers advocate for longer collaborative and discussion periods, such as 15 or 20 minutes, instead of shorter durations, like five minutes. When collaborative activities are too short (e.g., five minutes), "very likely your students sit there and wait for the answer or just work by themselves without interacting or collaborating with others", according to Teacher B. This extension of time aligns with SDT's emphasis on autonomy, as it provides students with a sense of control over their learning process. When given adequate time, students can engage in more interactive and collaborative exchanges, benefiting from the collective knowledge and insights of their peers. By contrast, shorter time frames may lead to passive participation or individual work without meaningful interactions, diminishing students' motivation and engagement.

In summary, the theme of providing resources for fruitful collaboration aligns with the theoretical framework of SDT. By offering cognitive inputs, such as guiding questions, hints, diagrams and sub-questions, teachers support students' competence and autonomy in the learning process. These resources facilitate focused discussions, comprehensive thinking and active participation. Additionally, allocating sufficient time for preparation and collaborative activities enhances students' autonomy and promotes more meaningful and engaged interactions.

Theme 2.4: Discussion Support for Effective Collaboration. The theme is about teachers' guiding students in their discussions using discussion-support tools and techniques, such as discussion protocols, sentence starters or discussion rubrics.

Evidence. During ERT, both teachers revamped the materials by redesigning the way the materials are presented. This strategy was developed in response to students who lacked collaborative skills and were relatively less fluent in English. This strategy assisted students by providing a simple discussion outline as well as helpful language tips for collaboration. Both teachers conducted their discussion activities in the same manner. Teacher A instructed her class to have one person state the main issue, then have each student take turns giving their opinions in each group. Following a round of sharing, students were free to interact by elaborating, asking questions and responding to one another. Similarly, Teacher B designated a group member as the leader, who posed the question, invited each student to respond and then expressed their opinion if it had not already been addressed. The leader then reported on the discussion's outcome to the entire class. The role of leader was rotated among group members throughout the semester.

Furthermore, both teachers assisted students by providing language tips (Appendix 8.2). Teacher B admitted that she overlooked the importance of language tips in her face-to-face teaching. During ERT, Teacher B created a Canvas page that provided language tips and discussion phrases. Teacher B recalled, "I made use of sentence starters. They are phrases that students can use to initiate their contributions during discussions, for example, I agree with you because . . . or one point I would like to add is . . .". She instructed the students to select the ones that best suited their communication style and use them during the discussion. Teacher A led the students in a mock debate. She remembered from one tutorial that "only one of them [the breakout rooms] was having the actual discussion. When I entered other rooms, students were either silent or pretended to be discussing the issue". She called a halt to the activity in the breakout rooms and moved everyone back to the main room. She invited the group that had previously discussed the issue to do so again in front of everyone. She asked other students to observe and record how students asked questions, agreed with others, disagreed with others, initiated a new point, elaborated on the argument, politely interrupted others and so on.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? Discussion support for effective collaboration, such as assigning a leader and providing language tips, can be understood through the lens of SDT. Teacher A assigning a leader with a predetermined flow of the discussion aligns with the SDT principle of autonomy, as it allows "shy", "introverted" or "disengaged" students to express their opinions and reduces the likelihood of 'free riders'. By preventing any single student from dominating the entire discussion, the strategy provides an equal opportunity for each student's participation, fostering a sense of autonomy and competence.

Teacher B's observation that having a leader makes the discussion more structured and balanced resonates with the need for relatedness, another key aspect of SDT. Ensuring that each student participates in the discussion promotes a supportive and inclusive collaborative environment, enhancing students' sense of relatedness to their peers and fostering a positive social context.

Moreover, the language tips provided by both teachers can be connected to the competence aspect of SDT. According to Teacher A, "international students usually have a higher academic standard, but their issues are social and collaboration". By equipping students, particularly international students facing social and collaborative challenges, with language resources, teachers support their competence in participating effectively in discussions. When students use the language phrases they learn from each other, they experience a sense of accomplishment, reinforcing their competence and further motivating their active engagement in collaborative activities.

Additionally, Teacher B emphasised that language skills are more important online than in on-campus collaborative activities. "In a face-to-face scenario, your body language, like your hand gestures and facial expression, can signal others more readily about your reactions, whether they are agreement, disagreement, or if you want to interrupt", she reasoned. "You can give firm eye contact to a specific person to show your agreement", she explained, "but in the online environment, when you give eye contact, you are giving it to everyone". This aligns with SDT's emphasis on competence as a driver of motivation and engagement. By mastering language tips, students can enhance their competence in online collaboration, leading to increased autonomy and relatedness as they effectively express their ideas and connect with others.

In summary, the discussion support strategy connects well with SDT. Assigning a leader and providing language tips align with the principles of autonomy, relatedness and competence. By promoting students' autonomy, facilitating a sense of relatedness and enhancing their competence, this strategy can foster effective collaboration and create a motivating and inclusive learning environment.

Theme 2.5: Maintain the Same Group Members Throughout the Semester. The theme is about teachers' having students work together in the same groups or teams over the course of a semester.

Evidence. Despite the icebreaker activities, both teachers agreed that students in the online environment did not have as many opportunities to make friends and connect as on-campus students did. Both teachers recognised the significance of having the same students in the same groups. Teacher A kept track of group membership on Canvas, to which students have access. When the breakout-room activity was about to begin, Teacher B kept a list of group members and displayed it on the screen. Students could then enter the breakout rooms based on their allocation. Throughout the semester, both teachers reminded students to exchange contact information so that they could connect on social-media platforms such as WhatsApp, Instagram and WeChat.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? Working with the same set of members allows students to form bonds with one another, which aligns with the concept of relatedness in SDT. According to Teacher B,

> *One of the big advantages is that students become more comfortable with group members over time, you know? They get to know the strengths and weaknesses of each other, learning how to work together better. This familiarity helps with communication and collaboration within the group, you know? Like, they can really talk and work together, you know?*

This sense of familiarity and connection with their peers contributes to students' satisfaction and motivation to work together. They are more likely to be happy collaborating with familiar faces, as they feel a sense of control and belonging within the group.

Assigning students to groups at random in a breakout room may not be conducive to collaborative learning. Teacher A explained that students feel "uncomfortable when randomly assigned to a group to chat with *strangers*" because they lack familiarity and control. This aligns with the need for relatedness in SDT.

Teacher B agreed that

> *when students are placed in a new group, they must reacquaint themselves with one another, and different students have different working styles. The discussion is over by the time they get to know each other and adapt to each other's styles*,

making effective collaboration difficult.

In addition, both teachers recognised the potential for students to continue communication and collaboration through social media groups. This connection to external platforms can further enhance students' sense of relatedness and autonomy. Teacher A mentioned that students have used social-media platforms to rehearse presentations, share study notes and create study groups for exams. This use of social media aligns with the need for autonomy, as students take the initiative to connect and collaborate beyond the confines of the classroom.

Overall, maintaining consistent group membership fosters a sense of relatedness and autonomy among students, facilitating effective collaboration. By allowing students to build relationships and adapt to each other's working styles, this approach promotes a positive learning environment. Furthermore, leveraging social media platforms provides students with opportunities to exercise autonomy in their collaborative endeavours and extend their interactions beyond the boundaries of the classroom.

Theme 3: Needs-Supportive Motivating Strategies that Address Independent Learning

Independent learning plays a vital role in empowering students to take ownership of their educational journeys. Theme 3 focuses on strategies aimed at fostering and supporting independent learning in the online learning environment. Theme 3 encompasses four subthemes: fostering relevance (Theme 3.1), offering choices (Theme 3.2), providing timely feedback (Theme 3.3) and promoting self-reflective practice (Theme 3.4). By exploring the meanings and evidence of subthemes, valuable insights into effective needs-supportive strategies that can nurture independent learning among students are gained.

Theme 3.1: Fostering Relevance. The theme refers to teachers' efforts to make learning content and activities meaningful and relevant to students' lives and real-world contexts.

Evidence. Teachers have long fostered relevance as an autonomy-supportive strategy. During ERT, both teachers adapted and modified the strategies for online delivery. Below are three examples of teachers' creating online activities that foster relevance to students' daily life events, study and career goals.

In the Pre-ERT era, the task was to collect Body Mass Index (BMI) measurements from peers in the classroom. Teacher B modified the task better to align the learning with the student's online learning experience. Instead of peers, Teacher B asked students to record their family members' body height and weight data and compute the BMI (Appendix 8.3). Students then analysed the data and used their knowledge to give their family members health advice, including exercise and diet plans.

Teacher A wanted her students to understand why learning the subject would help them in the future (Appendix 8.3). She listed all the second and third-year subjects from the student's study plan on the screen. She taught her students the definitions of the subject names, such as haematology (the study of blood). Using Zoom's poll system, she asked the students to identify which subjects would benefit from a foundation in cell biology in their current subject. Similarly, Teacher B has a modified discussion activity in which students are asked to use the levels of body organisation (from cells to tissues, organs, organ systems and organisms) to understand why they study cell biology, human anatomy and physiology and biocomplexity (Appendix 8.3).

Since ERT, both teachers started using online discussion forums to establish the relevance of learning to student career goals (Appendix 8.3). When designing the forum questions, both teachers intentionally included questions about students' career or personal interests. For example, students were asked why technical skills related to microscopy are critical to the work of pathologists. Teacher A wanted her students to learn about the heavy use of microscopes in pathologists' daily work through this exercise "so that students could excel in their skills in microscopy". Teacher A argued that "when students can see the connection between what they are learning and their own lives, it ignites their curiosity and motivates them to engage deeply in the content". Teacher B assigned her students the task of researching the educational requirements for becoming a registered chiropractor in Australia. Teacher B hoped that, by searching, students would realise that human anatomy and physiology are prerequisites for Master of Chiropractic programmes and that they would be able to connect their studies with their potential future career goals.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? Fostering relevance in online learning supports the principles of autonomy, which is an essential element of SDT. When students perceive the tasks or activities as personally relevant, they are given greater control and autonomy over their learning. For example, the BMI activity was modified and structured not only to be more suitable for online learning at home but also to reflect the students' interests. Teacher B noticed that students were concerned about the outcome of the BMI activity and provided carefully crafted diet and exercise plans for family members whom "they care about". From the poll results, Teacher A could see that students had made "connections from this subject to other subjects". She thought this activity was beneficial because "students can see the subject is relevant to their future learning, set higher goals, engage more and sustain longer learning". Students responded enthusiastically to the discussion forum activities, focusing on the connection between the subject and a future career. The post elicited responses from nearly every student in the class. Even though international students give her the impression that "I can learn for you no matter what", Teacher A explained that the discussion activities "opened a door for them to think about their [career] goal . . . and gave students a better idea of what they want to be".

Teacher B expressed the same viewpoint, saying that students "require workplace relevance. They'd wonder, what does it do for me? and why should I bother studying this?". Answering these questions "motivates them [students] to study the subject and set goals for their future". When students can connect the subject matter to their own lives, interests, or future goals, they can exercise choice and agency in their learning journey. This autonomy empowers students to take ownership of their studies, set their own goals, engage in independent study and sustain their concentration in learning without relying solely on external guidance or supervision.

Theme 3.2: Offering Choices. The theme refers to giving students options and opportunities to make learning decisions.

Evidence**.** Since the beginning of ERT, both teachers started to create more comprehensive concept pages so that students could gain conceptual understanding before attending tutorials. A feature shared by both teachers' concept pages was the availability of at least two resources for one single concept (Appendix 8.3). Video clips, e-textbook readings, simulations, home projects or experiments and interactive quizzes are among the options. Students were free to choose their preferred method of learning the concept at any time and from any location.

At the same time, students were allowed to complete their learning any time before the scheduled tutorial. For example, Teacher A's concept page allowed all students to explore basic cellular structures and functions asynchronously on their own (Appendix 8.3). During the tutorials, Teacher A and the students then co-constructed their understanding of more advanced concepts, such as the endomembrane system. One example from Teacher B's concept pages was the five key transitions in animal evolution, where students work by themselves in the asynchronous environment (Appendix 8.3). The concept pages began by establishing activities for students to explore the meanings of symmetry, germ layers, body cavities, body development and segmentation. The students then worked together in the tutorial to figure out the details of each change by looking at examples of animals from various phyla.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? Providing choices in online learning aligns with the principles of SDT and can support students' independent learning by fulfilling their autonomy needs. By offering options, teachers meet students' need for control and enable them to make decisions regarding their learning experiences. Teacher A emphasised that students have diverse learning styles, and providing choices allows them to select the methods that best suit their preferences and enhance their concentration. Teacher B supported, saying, “Some prefer simulations, some enjoy watching a video, and some gain more when they do it hands-on”. Teacher B emphasised that students should have agency and ownership over their learning experiences. She stated, “They [students] are in charge of their own education. They have the right to choose the best one for them, something they enjoy and can concentrate on while learning. They have control over it”.

Providing options also addresses the challenges students faced during the COVID-19 pandemic, fulfilling students’ need for relatedness. Teacher A mentioned that “some of my students had mild COVID symptoms and could not attend the tutorials. I need to make something to help students catch up”. In response, the availability of alternative learning materials helped these students catch up. This act of understanding and accommodation fosters a sense of relatedness between the teacher and students, as it communicates that the teacher cares about their well-being and is committed to their academic progress despite the obstacles they encounter.

Additionally, Teacher B highlighted the issue of poor internet connections among students in certain suburbs. Teacher B stated, “My students in some suburbs have bad internet connections. They may also compete with their siblings for the computer. For various reasons, they miss the tutorials”. By allowing each student to choose his or her preferred time and method of learning, teachers demonstrate concern, care and understanding of their unique situations. The choice of when to engage in learning activities is also important. Teacher B acknowledged that students often desire more time and the flexibility to choose when and how long to work, which empowers them to learn and complete tasks at their own pace. Teacher B stated, “Time is never enough for academically less capable students. The ability to choose when and how long they work gives them opportunities to learn and complete tasks”. This flexibility benefits students less proficient in English, who may require additional time for language translation and comprehension. These accommodations acknowledge and respect each student's individual circumstances, promoting a sense of relatedness in them.

Student participation data support the effectiveness of providing choice and, in turn, promoting student competence. Teacher A reported that 75% of her students completed the pre-tutorial concept activities, indicating their preparedness for tutorial sessions. Similarly, Teacher B observed a nearly 100% completion rate in some classes, illustrating that students took the initiative and successfully managed their work at their preferred pace. These data indicate that, when students can choose their preferred learning methods, time and pace, they are more likely to feel competent in their abilities to complete tasks and achieve their desired outcomes.

Theme 3.3: Providing Timely Feedback. The theme emphasises the importance of providing students with personalised and timely feedback.

***Evidence*.** In the Pre-ERT era, both teachers recognised the importance of feedback for student improvement. When Teacher A was teaching on-campus classes, she recalled, "I provided individual feedback on the scientific report, but I couldn't do the same on the paper tests or quizzes, where there are many multiple-choice questions". Moving to online teaching has given both teachers more opportunities to expand their feedback from scientific reports to questions in weekly quizzes. After creating several online quizzes, both teachers began to consider how to support students with varying levels of achievement. Since the Canvas quiz allowed teachers to provide feedback on the question and option levels in text or video, both teachers have begun creating tailor-made feedback for each question (Appendix 8.3). Teacher A said:

> *I designed an online quiz that assessed students' understanding of cellular processes. As soon as students completed the quiz, the platform provided detailed feedback, explaining why certain answers were correct or incorrect. This instant feedback allowed students to reflect on their knowledge gaps and revise their understanding. I noticed that students who received*

immediate feedback were more likely to address their misconceptions promptly and demonstrate improved performance in subsequent assessments.

If students chose the incorrect answer, they were given video or written feedback explaining why, or hyperlinks to the concept pages for them to work out how they had erred.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? The provision of feedback plays a crucial role in fostering independent learning. Both teachers recognise that timely and constructive feedback helps students reflect on their performance and motivates them to improve. Teacher A highlighted that feedback stimulates students to engage in self-reflection, enabling them to identify areas for growth and take ownership of their learning process. This aspect is closely aligned with SDT's emphasis on autonomy, as students are encouraged to consider how they can enhance their own performance and take proactive steps towards self-improvement.

Teacher B also emphasised the importance of specific feedback tailored to individual learners, as it replicates the effectiveness of private or one-on-one tutoring. By providing more targeted feedback at the question and option levels, Teacher B believes that students can receive valuable guidance on how to enhance their understanding and become independent learners. This approach supports SDT's tenets of competence and autonomy, as students are equipped with the tools and insights to drive their own learning journeys and develop a sense of mastery in their academic pursuits.

Theme 3.4: Promoting Self-Reflective Practice. The theme involves encouraging students to reflect on their learning process and outcomes.

Evidence. Teachers set up activities to develop students' reflective capabilities. Teacher A assigned three reflective tasks to her students. The first one asked students to share their strengths and weaknesses so that they could set goals for the semester (Appendix 8.3). The second one, in

Week 6 (out of 11), asked students what they had done well and what they had not done so well so that they could recognise their success while also identifying areas where they needed to improve. The final one was to gather feedback on the course materials at the end of the semester, specifically asking students which assessments improved their knowledge and skills in the subject. The final one is important, as the formal student feedback survey does not explicitly address this question.

For her students, Teacher B developed a weekly ‘confidence checklist’ (Appendix 8.3). According to her, the word ‘confidence’ gives students the impression that the checklist is more relevant and personal to them. She said:

> *One tool I used was confidence checklists, which helped students assess their understanding and confidence in specific learning objectives. Through these checklists, students could identify their strengths and areas for further improvement, allowing them to take charge of their own learning.*

The checklist is a slightly modified version of the lesson objectives. The number in brackets at the end of each objective denotes the level of response required. For example, ‘the significance of coronary circulation? (3)’ indicates that students need to make three valid points about the significance of coronary circulation. Students went through a mental practice to see whether they could provide three points about this objective. If they do, they rate themselves ‘confident’. If not, they can rate themselves as ‘in progress’ or ‘no idea’. Based on the checklist, the teacher could determine whether certain concepts needed to be reviewed again in the next tutorial, and the student could know which concepts they needed to review.

How Did This Strategy Address the Online Learning Challenge by Meeting Students' Psychological Needs? In accordance with the principles of SDT, both teachers in the programme recognised the significance of promoting self-reflective practice to facilitate their development as independent learners through meeting their psychological needs for autonomy. The reflective tasks in the discussion forum set up by Teacher A enabled students to assess their strengths and weaknesses, set goals for the semester and reflect on their progress. By engaging in self-reflection, students gain a clearer understanding of their successes and areas for improvement, empowering them to take ownership of their learning journeys. This practice aligns with SDT's emphasis on autonomy, as students are encouraged to recognise their own progress and identify areas where they can enhance their performance.

Additionally, the use of a discussion forum for reflection provided students with a record of their growth and encouraged them to revisit and expand on their previous reflections. Teacher A stated:

> *Students can see each other's feedback when they share their reflective thoughts on the discussion forum. I hope that, by reading each other's comments and feedback, they can broaden their thinking in terms of scope, perspective and depth. The forum also allows students to expand on their previous reflections by drawing on the feedback of others*.

This practice enhances students' relatedness, as they engage in a collaborative and supportive learning environment that fosters the exchange of ideas and constructive feedback among peers.

Teacher B emphasised the benefits of the confidence checklist in developing students' reflective abilities. By clearly indicating the next steps and areas for improvement, the checklist empowers students to create personalised plans to address their weaknesses. This practice supports SDT's principles of autonomy and competence, as students actively engage in self-assessment, set goals and take responsibility for their learning progress.

Overall, this study contributes to the growing body of knowledge on effective online teaching strategies and highlights the importance of supporting students' psychological needs in the online learning environment. This study has identified 13 needs-supportive strategies that have been perceived by teachers as effective in assisting university pathway students in online learning during

ERT. These strategies address various aspects of online learning, including sustaining concentration, promoting collaborative learning and encouraging independent learning. The strategies align with the principles of SDT by promoting students' competence, autonomy and relatedness.

Development of Teacher Self-Efficacy Beliefs in Online Teaching

According to Bandura (1977), self-efficacy is the belief that one can carry out a specific task or achieve a particular goal. This study explored how teachers develop their self-efficacy beliefs, specifically in the context of online teaching. As discussed in the literature review, despite online education being the prevalent mode of learning during the pandemic, understanding how teachers developed their self-efficacy during the sudden shift from face-to-face to online teaching was unclear. This study addressed this gap by exploring teacher self-efficacy development for online teaching, which has important practical implications.

Throughout the second semester of ERT, both teachers expressed that they both experienced growth in self-efficacy in online teaching. This study draws upon Bandura's (1976) four sources of self-efficacy belief: mastery orientation, vicarious experience, verbal persuasion and emotional states to understand its growth by identifying key factors in each influencing teacher self-efficacy in online teaching.

Theme 4: Mastery Experiences

Of the four sources, mastery experiences appear to be the leading contributing source to teacher self-efficacy in online teaching. Teacher A said, "it all comes down to experience, experience and experience". Teacher B also emphasised the importance of "learning by doing". These mastery experiences result from the use of motivational strategies prior to and during ERT (Theme 4.1), the creation of engaging online resources (Theme 4.2), the online monitoring of student engagement and achievement (Theme 4.3) and finally the ability to reflect on their experience (Theme 4.4).

Theme 4.1: Experiences in Using Strategies Before and During the ERT. Teachers stated that their success with strategies had given them the confidence to modify the strategies for online learning during ERT. Teacher A stated that, “if you know something worked before, it will also work in another medium”, and she was “confident” that the “same strategy used online” could achieve similar success. Teacher B agreed, saying that “certain strategies or teaching methods can be used in both face-to-face and online scenarios”. Importantly, Teacher B proposed that “some strategies, such as those discussion structures and support [Themes 2.3 and 2.4], are even more important for online learning because these strategies ensure collaboration takes place in the breakout rooms”. According to Teacher A, “If you see that most of your students have used the resources, you will be overjoyed, and you will think, yes! I must be doing something right!”. Teacher B said, “When you know your students like the resources, it is a big yes!” The successful use of motivational strategies prior to and during ERT increased teacher self-efficacy in online teaching.

Theme 4.2: Experiences in Designing Engaging Resources Online. Experiences with using online tools to create engaging learning materials are critical to building teacher self-efficacy in online teaching. During ERT, both teachers realised that Canvas, the learning management system, was more than just a place to store files, such as PowerPoint files for lessons and assignment submissions, but also a platform for effective teaching and learning. This was not something of which they were unaware; it was simply how the learning management system had always been perceived and used. Teacher A felt “empowered” and “confident” about teaching online because she could “create digital resources” to help her students “focus” on their learning, “work well with others in tutorials” and “enjoy learning in their way and pace” on Canvas. One example of the strategy is breaking down complex ideas into manageable chunks (Theme 1.1). Teacher A had already structured her lesson worksheet to break down complex concepts into bite-size chunks when teaching face-to-face. She moved more live lesson materials from the lesson worksheet to the Canvas environment for asynchronous learning during ERT. She recognised that more appropriate visual aids could improve the asynchronous learning experience for students. As a result, her experiences creating content online and engaging students successfully were critical to developing her self-efficacy in online teaching.

Theme 4.3: Experiences of Monitoring Student Engagement and Achievement Online. Both teachers stated that their self-efficacy in implementing specific new online strategies stemmed from their experience monitoring online student engagement and performance. This experience is well illustrated by the example of when they implemented the strategy by providing options for when and how to learn. As stated previously, both teachers were sceptical at the start of ERT, unsure of whether students were "actually" learning online. Both teachers were fortunate to discover that there were online tools for understanding and monitoring learner engagement. Teacher A stated that she could "use Canvas analytics to understand how students learn the materials online and how they participate in online tasks, like quizzes", as well as see "the amount of time spent on Canvas and the number of pages viewed in that week". Teacher B agreed, saying she was familiar with various online tools for understanding "student participation, emotions and academic development". Teacher B could use these analytics to understand and monitor "whether they [students] have watched the videos; whether they have opened the resources, like reading and simulations; and the performance in quizzes". According to Teacher A, "It's good to know that some students did not watch the video or read. At the very least, I now have evidence to show my students that you have not been doing this or that. This is something I could not tell before using these analytics". Teacher A went on to say that there were "more indicators available online than face-to-face (on campus)" to understand learner engagement and achievement. As a result, being able to monitor student engagement and achievement as part of the mastery experience of teachers contributes to their self-efficacy in online teaching.

Theme 5: Vicarious Experiences

Both teachers stated that seeing others succeed in online teaching gave them the confidence to teach online. Professional development activities and observing lessons taught by other colleagues provided them with these vicarious experiences. Their responses emphasised that context- and practice-oriented professional development were key to whether vicarious experiences effectively increased their self-efficacy.

Theme 5.1: Suitable Contexts. Both teachers agreed that observing others with similar backgrounds and teaching contexts could boost their self-efficacy in using similar strategies in online teaching. Teacher A remembered “students making study notes when learning online” from a colleague who taught chemistry. She said, “Seeing the actual notes made by the students has given me comfort and confidence that this is working, and hearing about the technology glitch experienced by others has given me clues on how to avoid them”. She continued, “If someone you already recognise as effective in your eyes uses those strategies, you feel more comfortable using them”. Teacher B observed an online lesson taught by a science colleague who taught the same class of students as she had earlier in the semester. The lesson inspired her to use a confidence checklist to help students self-evaluate their weekly results. She found it “useful”, she said, explaining that “the context is similar, and the student composition is similar to mine. What works in that subject should work in my subject as well”. “Observing a communication or social science subject could be inspiring”, she continued, “but the pedagogy is different; it may not be useful in my teaching”.

Theme 5.2: Practice-Focused Professional Development. Both teachers agreed that professional-development activities that focus on practice could boost their confidence in teaching online. They found professional-development seminars on learning models or online learning theories “not particularly helpful” (Teacher A). She elaborated, “Models or theories may be of interest to other stakeholders. As a teacher, I urgently need to implement effective strategies for engaging my students". Teacher B also discovered that practice-related sharing "resonated" with her more and explained that the successful strategies demonstrated by her colleagues were more "convincing", providing her with self-efficacy in implementing those strategies in her online teaching.

Theme 6: Verbal Persuasion

Verbal persuasion, oral or written feedback, played a vital role in building both teachers' self-efficacy beliefs. Although student feedback has always been an important source of verbal persuasion, they responded to the Student Feedback Survey only after completing the entire course. During the pandemic, opportunities to gauge students' feedback on the course were even more limited compared to during on-campus teaching.

Instead, during ERT, both teachers in this study gained verbal persuasion primarily through interactions with credible others in their support networks. These credible others included family members for Teacher A and colleagues for Teacher B. Based on both teachers' account, credible members appear to be someone who have experience and/or interest in teaching and learning.

Teacher A demonstrated the concept pages to her daughters, shared the video clips she discovered for the concept, asked them to try the interactive quizzes and simulations and conducted home experiments in the kitchen. Teacher A explained that her daughter's early feedback was critical to her and that,

> *they are now the guinea pigs of my online course. They tell me what works and what needs more work. They tell me whether or not they like it. They told me what typical teenagers thought of this online curriculum*.

Teacher A's daughters' feedback clearly gave her the self-efficacy she needed and pushed her to 'go the extra mile' in developing her online curriculum. Such a proactive approach to seeking external perspectives and using them to enhance her teaching effectively allowed Teacher A to develop her self-efficacy in online teaching through verbal persuasion. Teacher A’s willingness to share and seek feedback from her teenage daughters also highlights her openness to collaboration and continuous improvement in her online teaching practices.

Teacher B shared her Canvas course with two colleagues she considered competent teachers and asked them for feedback. This sharing has involved her in professional dialogues, evaluating the online learning design and providing an opportunity for others to persuade her verbally. On the online professional-development day, she also shared her online practice and received oral feedback from colleagues. She demonstrated her home experiment task by making a model of pollination and seed dispersal strategies. She was “moved” and “rewarded” after receiving positive feedback from colleagues. The compliments and comments, particularly those from those teachers she regarded as exemplary, “energise” her to “sustain my effort in the continuous improvement of my course”. This example also demonstrated that, by actively involving colleagues in the evaluation of her course and being receptive to their perspectives, Teacher B gained verbal persuasion, developing her self-efficacy in online teaching.

The responses above indicated that the more willing teachers were to share their ideas and strategies with others, the more likely they were to receive the verbal persuasion required for self-efficacy development. The verbal persuasion they received from others provided them with the necessary validation and encouragement, further strengthening their confidence in their online teaching practices.

Theme 7: Emotional States

During ERT, both teachers faced challenges that could elicit negative emotions. Both were able to regulate their emotional states by balancing negativity with positivity (Theme 7.1). Furthermore, they enhanced positive emotions by honouring their passion, adapting to the situation, and reflecting on their experiences (Theme 7.2), which helped them develop the self-efficacy required in the context of online teaching. Together, the positive emotional states helped both teachers remain optimistic and confident in what they needed to do and energised them to complete the tasks even when the online teaching environment became challenging. More importantly, both teachers highlighted the more influential and precursory role of emotional states on the growth of self-efficacy before other sources (mastery experiences, vicarious experiences and verbal persuasion) could come into contribution.

Theme 7.1: Balancing their Negativity with Positivity. Teachers shifting negative emotions into positive emotions can empower them to build self-efficacy. Teacher A described the pandemic as “sad” and online teaching as “lonely”. She realised that “more work needs to be done” when teaching moves online. She said:

> *Looking on the bright side, I no longer have to commute, which saves me three hours per day or fifteen hours per week. I can use these extra hours to work on my online materials or improve my health by walking in the park or doing yoga at home. So, I believe it is reasonable and attainable*.

Teacher A’s response suggests that having a positive emotional state (“looking on the bright side"), made her feel easier and better to enjoy the mastery experience (“work on my online materials”), indicating positive emotions as a precursor to a mastery experience.

When dealing with loneliness, she admitted,

> *I have fewer interactions with colleagues now, but I have more time to see and talk to my daughters. My bond with them has grown stronger. They are now the guinea pigs for my online course, and their responses and feedback provide me with confidence, certainty and courage in my design*.

Similarly, Teacher A shifted her emotions from feeling isolated from colleagues to feeling more connected with her daughters. The feeling of a stronger connection allowed her to trial her online materials with her daughters (mastery experience) and be open to their feedback (verbal persuasion). In turn, their feedback gave Teacher A's certainty and courage—a sense of success—in online material development. This quote also suggests that positive emotions are a precursor to other sources, contributing to the growth of teacher self-efficacy.

Managing negative emotions and focusing on positive emotions has also given Teacher B a new perspective on online teaching and thus increased her self-efficacy. During online teaching, Teacher B expressed negative emotions, such as "stressed" and "urgent". The negativity has not defeated her, however. She hung appreciation cards from previous students on the monitor to keep "positive feelings floating around my work environment, or, you should say, home environment". She saw the bright side by realising the advantages of online education, including, for example, more tools "to support student learning, meet individual needs and monitor student engagement". She believed that COVID had accelerated the development of online or remote learning. Thinking positively, she discovered that the online teaching experience provided her with "another skill set", allowing her to feel "confident" that she could be an effective teacher both online and in person in the future. As such, Teacher B's positive emotions also acted as an antecedent, allowing her to acquire more mastery experiences (developing tools "to support student learning, meet individual needs, and monitor student engagement").

Theme 7.2: Enhancing Positive Emotions. Data revealed three ways teachers enhanced their positive emotions: honouring passion, being adaptable, and remaining reflective about teaching. This subsection not only presents evidence of these three positive emotions from teachers' accounts, but it also suggests how positive emotions serve as precursors to other self-efficacy sources, thereby promoting teacher self-efficacy in online teaching.

Passion. Passion in teaching can be seen as deep enthusiasm for teaching. Teacher A said:

The whole switch to online teaching caught me totally off guard! But my love for teaching stayed rock solid. I've always believed that education is a powerful tool, and I was determined to continue inspiring and supporting my students, even in the virtual environment.

Teacher B also said, "remember why you became a teacher in the first place and let that passion guide you".

Teachers' passion for teaching can be seen across different elements of online teaching. Their high investment in time and effort to revamp online teaching design and materials (mastery experiences) was contributed by their passion (emotion). The results of this were provided in the sections addressing Themes 1.1 to 3.4. Moreover, their passion could also be seen in their online interactions with students (mastery experiences). Both teachers actively engaged with their students during collaborative synchronous sessions: i.e., the online Zoom tutorials (see Theme 2.3). In an asynchronous environment, both teachers ensured that the learning is relevant for students (see Theme 3.1), provided feedback to students in online discussions and created automatic feedback for online quizzes (see Theme 3.3), thus fostering a strong sense of engagement outside of timetabled tutorials. Finally, both teachers participated in professional-development activities, not only to learn from others (vicarious experiences), but also to share their practices with others and receive feedback (verbal persuasion) for ongoing improvement (see Theme 4.3).

Adaptability. Teacher adaptability in online teaching can be viewed as the ability of educators to adjust and modify their instructional practices, strategies and approaches to effectively meet the changing demands and challenges of the online learning environment. It involves being flexible, resourceful and open-minded in response to new technologies, student needs and unforeseen circumstances that may arise during online instruction. Again, being adaptable (emotion) appears to be a prerequisite for other self-efficacy sources to occur.

Both Teachers A and B demonstrated their adaptability in multiple areas, the first being technological proficiency. Both teachers could quickly adapt to and were proficient in using technology. As Teacher B recalled, “Certainly, the transition was not without its challenges. I had to learn new technologies and overcome occasional technical glitches”. Both teachers even designed activities to help their students master these technologies to enhance their competence and ability to collaborate with others (Theme 2.1). This example demonstrated how harnessing adaptability to technology allowed teachers to design activities (mastery experiences) that assist students in overcoming technological challenges.

Another area showing a strong sign of adaptability is the online pedagogy implemented by both teachers. Nine of 13 strategies identified in this study were adapted and modified from the pre-ERT era, suggesting that both teachers were willing to adjust their strategies to suit the online environment. Teacher A recalled:

> *The transition to online teaching has been a transformative journey for me. It has made me more open to innovation and more receptive to change. I’ve learned to be flexible and adaptable, and it has reinforced the importance of creating a supportive learning environment for my students, regardless of the teaching format*.

These examples demonstrated how adapting emotions to new situations—online learning—motivated teachers to seek various mastery experiences to boost their self-efficacy in online teaching.

Being Highly Reflective. Being reflective meant that both teachers regularly engaged in a process of self-assessment, evaluation and thoughtful consideration of their teaching practices and experiences in the online teaching environment.

Teacher A kept a spreadsheet with her reflections on student participation in asynchronous Canvas activities, synchronous tutorial activities and assessment design, recording “what worked, what didn’t and areas of improvement” every week. Teacher B reflected on her practice in her notebook and said that "the reflective log has made me visualise what works and gives me the confidence that the same level of success will likely happen in the next round". As the semester progressed, both teachers entered a cycle of continuous improvement. Being reflective also allowed them to learn from others. Both also engaged in discussions and sought feedback from others on teaching strategies, challenges, and successful practices to gain insights and new perspectives (see Theme 6). These examples importantly show that the act of reflection served as a positive emotional component that enhanced mastery experiences for teachers as well as verbal persuasion, allowing them to gain self-efficacy in online teaching.

This section presented how teachers enhanced positive emotions during the ERT and, more importantly, demonstrated that positive emotions appear to be precursors to other sources of self-efficacy. This finding implies that emotional states could have played a more influential role by enhancing other sources of self-efficacy in promoting overall teacher self-efficacy in online teaching.

Overall, this section illustrates the teachers' process developing their self-efficacy beliefs in the context of online teaching. Specifically, the factors that contribute to teachers' self-efficacy in each source, including mastery orientation, vicarious experience, verbal persuasion and emotional states (Bandura, 1976), were explored in online teaching. These findings highlight the dynamic and multifaceted nature of teachers' self-efficacy development in the online teaching domain.

This chapter has provided valuable insights for designing and delivering effective online teaching through a comprehensive exploration of research questions focused on how science teachers adapted instructional strategies to promote student engagement during ERT and how science pathway teachers developed their self-efficacy in the online learning environment. The findings shed light on the strategies employed by science teachers to address the challenges of online learning, including sustaining concentration, facilitating effective collaboration and fostering independent study. Moreover, the research has highlighted the process through which science pathway teachers who lacked prior experience in online teaching developed their self-efficacy to effectively engage students during the rapid transition from face-to-face to online delivery. By gaining a deeper understanding of these processes, teachers can enhance their instructional practices and support students' engagement and learning outcomes in the online learning environment (see Chapter 5 for details). The insights from this study are expected to contribute to the alleviation of disengagement and attrition issues in science education, ultimately leading to improved educational outcomes for students.

Chapter 5: Discussion

The present research aims to understand the disappointing student engagement in online learning during the COVID-19 pandemic. This is especially critical in programmes with historically high dropout rates, such as science in the Australian university pathway programmes (TEQSA, 2017). Many students reported that they could not maintain their concentration, collaborate effectively, or complete the required independent study during online learning (QILT, 2021; TEQSA, 2020). These difficulties highlight the need to better understand how pathway teachers used strategies to address these difficulties and allow a high level of student engagement in online learning. The abrupt shift in delivery from face-to-face to online also necessitated a closer examination of the sources from which teachers gained self-efficacy in online teaching during the pandemic. Moreover, as online learning is likely to become an integral part of educational practices beyond times of lockdown (Breslin, 2023), research on needs-supportive strategies for online teaching and teacher efficacy in online teaching will remain relevant in the post-emergency remote teaching (ERT) era. To address the overall question of 'how do pathway teachers support student engagement in online learning during ERT?', this study specifically sought to answer the following questions:

1. How did science pathway teachers support student engagement and success in online learning during ERT, specifically addressing challenges in concentration, collaboration and independent study?
2. What factors contributed to science pathway teachers' self-efficacy for online teaching during ERT?

This chapter first summarises and discusses the results to provide empirical implications. This is then followed by theoretical implications and practical implications. The chapter then discusses limitations and recommendations for future research.

Summary of Key Findings

This study focused on the strategies implemented by two teachers to assist university pathway students during ERT. As shown in Table 4.1, thirteen strategies (Themes 1.1–3.4) were identified, including five on collaborative learning and four on sustaining concentration and independent learning. Based on SDT, it was found that 11 belong to the competence- and autonomy-supportive categories, while only six were relatedness-supportive. Additionally, it was observed that nine of the 13 strategies had been previously used successfully in face-to-face teaching before the ERT era. To adapt these strategies effectively to online learning, teachers made modifications to meet the specific requirements of remote online learning.

The findings also indicated that both teachers had developed teacher self-efficacy in online teaching throughout the ERT period. Drawing upon Bandura's four sources of self-efficacy belief, the study identified key factors involved in each source that can positively build up teachers' self-efficacy in online teaching. More specifically, teachers' mastery experiences in using needs-supportive strategies before and during (Theme 4.1), designing engaging resources online (Theme 4.2) and monitoring student engagement and achievement online (Theme 4.3) were found to be critical for building up their self-efficacy in online teaching. Regarding vicarious experience, the data suggest that context (Theme 5.1) and the practice-focused professional development (Theme 5.2) are critical. The data also revealed that the willingness to share their online teaching designs and strategies with credible others, is advantageous for gaining verbal persuasion (Theme 6). Finally, the data revealed that balancing negativity with positivity (Theme 7.1) and enhancing positive emotions through passion, adaptability, and reflectiveness in coping with the challenges of ERT (Theme 7.2) can help teachers develop self-efficacy when teaching online.

Empirical Implications

The section first focuses on three key findings related to needs-supportive strategies: i) the limited use of relatedness-supportive strategies; ii) most strategies adapted and modified from practice in the pre-ERT era and iii) how strategies address the issues of sustaining concentration, effective collaboration and independent learning. The section then discusses the key considerations for building teacher self-efficacy in online teaching.

Limited Use of Relatedness-Supportive Strategies

The results (Table 4.1) show that relatedness strategies were fewer in number (six) compared to both competence and autonomy strategies (11 in each), suggesting limited use of relatedness-supportive strategies by both teacher participants. There are three potential explanations for this finding. First, science teachers may view science learning as primarily being about acquiring knowledge and skills rather than developing personal relationships with their students (Hodson, 1992). The second explanation, relevant to the first one, may be related to the challenges science teachers face in developing strategies for remote teaching. Keebler and Huffman (2020) found that science teachers struggle to create opportunities for students to develop conceptual understanding and higher-order cognitive skills; therefore, relatedness-building may be less prioritised. Third, while relatedness-supportive strategies may be limited in science learning, they can still be satisfied through teacher–student interactions in synchronous online learning. For example, teachers can respond to students' questions or help-seeking behaviours in breakout room sessions by reinforcing, scaffolding or adapting instruction. A limitation of this study, however, was that Zoom could not record these moments in the breakout rooms, which may have resulted in fewer relatedness-supportive strategies' being reported. This is one limitation of the current study.

The lack of relatedness-supportive strategies in the online learning environment, particularly during the pandemic, can have significant implications for student engagement. In online learning, perceived relatedness is the primary predictor of behavioural and emotional engagement (Chiu, 2021). Emotionally, students whose relatedness needs are unsatisfied can feel less supported in the learning community, adversely affecting their social and emotional well-being (Juvonen, 2006;

Wentzel, 2002). Examples of this are feeling disconnected, isolated, lonely or stressed (Skinner & Belmont, 1993; Wentzel, 1998). These negative emotions can hinder the development of positive relationships with peers and impede their ability to communicate and engage in meaningful interactions (Ryan & Patrick, 2001), depriving students of a safe and supportive space for sharing ideas and receiving constructive feedback (Deci & Ryan, 1985). Behaviourally, the absence of relatedness-supportive strategies can result in reduced participation and limited collaboration, affecting their overall motivation. More importantly, behavioural and emotional engagement are prerequisites for cognitive engagement (Poskitt & Gibbs, 2010). In other words, cognitive engagement, i.e., the psychological investment in the learning process, is also hindered without satisfying the needs of relatedness in students. In parallel, it is noteworthy that competence- and autonomy-supportive strategies may not exhibit the anticipated efficacy or outcomes that both teachers initially expected. Therefore, the lack of relatedness-supportive strategies deserves further attention in science teaching and learning in the university pathway programme context and has implications for future studies.

Most Strategies were Adapted and Modified from Practice in the Pre-ERT Era

As discussed in Chapter 2, resilient pedagogy involves creating learning materials that are as needs-centred as possible, is adaptive, flexible and agile and would not crumble given a change in modality when facing disruptions (Thurston, 2021). The study identified 13 strategies, of which nine were already in use before ERT. This indicates that teachers were already implementing needs-supportive strategies in their face-to-face classrooms. When the disruption occurred during ERT, both teachers modified their existing strategies slightly to adapt to the online learning environment. For example, students explained complex concepts to one another in Zoom breakout rooms rather than in a group setting in physical classrooms (Theme 1.2).

These nine pre-ERT strategies identified meet Gardiner's (2020) mode-agnostic criterion for resilient pedagogy that strategies are appropriate whether the modality is face-to-face or online. In the post-ERT era, the mode-agnostic nature of resilient pedagogy may become more critical. Online technologies will significantly enhance and enable face-to-face learning after ERT due to the adaptations and implementations of online teaching across various educational contexts (Bashir et al., 2021).

The findings of this study, however, appear to oppose Gardiner's (2020) assertion that teachers only design 'once and only once' in resilient pedagogy. To better meet the needs of students, both teachers in this study devised at least four different need-supportive strategies that had not been implemented before ERT. This is not to question the nature or concept of resilient pedagogy but to emphasise the importance of teacher self-efficacy in developing their capability and confidence to design and implement appropriate needs-supportive strategies to help students cope in a changing learning environment. According to the findings of this study, both teachers developed self-efficacy for online teaching from various sources to become resilient.

Therefore, as this study shows, resilient pedagogy is more than just a mode-agnostic and needs-centric pedagogy; teachers must also develop the self-efficacy to be resilient enough to design strategies that can help students learn better in a disrupted environment. The COVID pandemic is just one of many unavoidable disruptions that have constantly threatened the academic success of our vulnerable students, particularly those in tertiary education pathway programmes. One important implication for teachers is the need to use the inevitability of these disruptions as motivation to build up their self-efficacy and devise needs-supportive strategies to maintain a teaching environment suitable for different modes of delivery for all students.

How to Address the Issue of Sustaining Concentration by Providing Needs-Supportive Strategies?

During ERT, teachers implemented the following four strategies to cope with the student's focusing challenge: chunking and checkpoints (Theme 1.1), deliberate rehearsal of concepts (Theme 1.2), information reorganisation (Theme 1.3) and kinaesthetic activities (Theme 1.4). All these strategies were applied in the asynchronous learning space except for the deliberate rehearsal of concepts (Theme 1.2). Both deliberate rehearsal and kinaesthetic activities were also used during synchronous live online tutorials.

These strategies, in terms of their principles and effectiveness, are supported by previous studies on maintaining learners' focus during their learning. Chunking (Theme 1.1) that breaks down multi-part, complex information into more manageable pieces can reduce the challenges experienced by learners; thus, learners are more likely to persist in and sustain their learning (Mayer & Moreno, 2010; Rosenshine, 1995). Deliberate practice (Theme 1.2) can reduce the dissonance between where the learner stands and where they aspire to be (Nandagopal & Ericsson, 2012). Information reorganisation (Theme1.3) is critical because students need to use energy to locate the information when it is scattered, reducing their ability to remain focused in the online environment (Sweller, 2012). Kinaesthetic activities (Theme 1.4) were consistent with previous findings (e.g., Greenspoon, 2001; Richards & Etkina, 2013; Sivilotti & Pike, 2007) that, when activities involve a high level of active and hands-on participation from students, their minds and bodies are in synchronicity, allowing them to engage better and preventing them from losing concentration during learning. While these previous studies predominantly focused on traditional face-to-face environments, this study has importantly demonstrated that these strategies can also be applied in the online learning environment in the context of pathway science programmes during ERT.

While these strategies agree with the previous findings, the current study also advances the existing strategies by finding a better implementation. For example, in chunking (Theme 1.1), both teachers designed an improved mechanism that enhanced the effectiveness of chunking: the incorporation of quiz questions on each Canvas page as checkpoints. These checkpoints served not only to allow students to visualise the completion of each chunk as a success but also to demonstrate their understanding in asynchronous learning settings. At the same time, teachers could monitor student learning—participation and performance—in the asynchronous environment, which other studies have claimed is challenging to monitor (Pasaribu & Dewi, 2021; Ratnadewi, 2021). Similarly, previous studies have shown that ensuring that students conduct deliberate practice (Theme 1.2) in the breakout rooms is challenging. Teachers in this study required students to submit evidence of rehearsal, such as the screenshot of the collaborative whiteboard in Zoom, mitigating this non-participation issue.

At the same time, while these strategies could potentially promote students' concentration in online learning, they should be used with caution, as presented by the evidence in this study. For example, in the deliberate rehearsal of concepts (Theme 1.2), as teachers from this study pointed out, this strategy's success relies heavily on providing constructive feedback. Some students may feel uncomfortable providing feedback to their peers whom they perceive to be more knowledgeable or skilled than themselves. Some students may hesitate to provide constructive criticism to their peers, fearing that they might hurt their feelings or create tension in the classroom. Another concern with this strategy was that students provided inaccurate or unhelpful feedback to their peers. Similar concerns have also been raised in previous studies (e.g., Hattie, 2012; Nandagopal & Ericsson, 2012), highlighting the need to prepare students to deal with the issue of power dynamics and the need to create rubrics when evaluating peers' performance in the rehearsal.

Information reorganisation (Theme 1.3) remains controversial in terms of how it can address factors, including the materials' complexity, the learners' cognitive abilities and the instructional context (Sweller et al., 2019). For instance, in highly specialised or technical subject matter, such as biological processes, where information needs to be presented precisely and structured, excessive integration may lead to oversimplification or the loss of essential details. Additionally, integrating materials may require careful planning as well as the expertise of teachers to ensure coherence and meaningful connections between different components (Clark & Mayer, 2016; Sweller et al., 2011). Finally, while integration may benefit learners by reducing cognitive load and enhancing comprehension, some learners may prefer fragmented information, where they can select suitable information for learning (Ayres, 2006; Mayer & Moreno, 2003).

It should also be noted that the effectiveness of kinaesthetic learning (Theme 1.4) may vary depending on the subject matter and learning goals. While it may benefit specific topics or subjects that lend themselves well to hands-on exploration, it may be less suitable or feasible for abstract or theoretical concepts that require more conceptual understanding or symbolic representation (Whitworth et al., 2014). Both teachers in this study admitted that kinaesthetic activities cannot be used with all topics. Therefore, other strategies, such as simulations, may be more effective alternatives. Specific to the online context, teachers in this study have also noted that running kinaesthetic activities in online classes can be challenging due to limited space (such as the body movement activities) and resources (e.g., materials are unavailable in local supermarkets for home experiments). Prior studies have raised similar concerns (e.g., Masela & Subekti, 2021). Therefore, more careful consideration and planning are needed when kinaesthetic activities are conducted with online students.

How Can Effective Collaboration be Enhanced through Needs-Supportive Strategies?

During ERT, teachers implemented the five main strategies to promote effective collaboration among students in the online setting: online collaborative tool familiarisation (Theme 2.1), promoting the benefits of collaborative learning (Theme 2.2), resources for fruitful collaboration

(Theme 2.3), discussion support for effective collaboration (Theme 2.4) and maintaining the same group members throughout the semester (Theme 2.5). All these strategies were conducted during synchronous online tutorials. Still, these strategies, especially online tool familiarisation (Theme 2.1) and maintaining the same group members (Theme 2.5), contributed positively to collaboration in an asynchronous environment.

These strategies are supported by previous studies on enhancing effective collaborations among peers. Familiarising students with online collaborative tools (Theme 2.1) agrees with researchers' (e.g., Chiu, 2021; Sherer & Shea, 2011) view of digital competence as a prerequisite for effective online learning and collaboration and is an action to address a pedagogical gap that tertiary teachers do not explicitly instruct their students on how to use online collaborative tools (Chiu, 2021; Rannastu-Avalos & Siiman, 2020). It is admitted that, while this study did not explore into the extent to which these digital competence skills translate into effective collaboration, both teachers in the study considered that this quick-to-implement strategy could at least reduce the collaborative barrier in the online learning environment.

Having students realise the benefits of collaborative learning (Theme 2.2) has always been an action item for teachers, and it is one they find it challenging to actualise (Lei & Medwell, 2021). Importantly, this study revealed that simply explaining the benefits of collaborative learning to students is not enough. Teachers need to provide guidance and stimuli to make students reflect on the benefits of collaborative learning. An example of this in this study was asking students to share what they know before and after the collaborative sessions so that they could realise the powerful effect of the collaborative learning.

Other strategies identified by this study were also consistent with previous findings. Providing suitable resources for collaboration (Theme 2.3), such as suitable scaffolds, guided questions, adequate time and reporting pro formas, to enhance student confidence in tackling collaborative tasks was in line with the findings of studies conducted by Reeve et al. (2004) and Rentroia-Bonito et al. (2006). Providing discussion structures (Theme 2.4), including assigning roles and language support, to prevent dominance and freeloading by members was also reported in previous studies (e.g., Hartnett, 2015). Maintaining the same group members (Theme 2.5) was also supported by previous studies (e.g., Rovai, 2007; Swan & Shea, 2005). Although group membership remained fixed throughout the same semester, Teacher B allowed students to form their own groups. Students' degree of choice in selecting group members could significantly enhance their motivation to collaborate (Van Etten et al., 2008), as students are more likely to value individual contributions and demonstrate mutually respectful and trustworthy attitudes (Xie & Ke, 2011).

As presented by the evidence in this study, while the above strategies appear to be effective at encouraging students' attention during online learning, they should be used with caution. Regarding the strategy of promoting the benefits of collaboration (Theme 2.2), it should be noted that Teacher A took a one-off approach, asking students to brainstorm the benefits. It is possible to question whether students in Teacher A's class might have initially engaged in collaborative learning due to heavy promotion but might eventually lose motivation or interest. Teacher B took a continuous approach to monitoring whether students still saw the benefits of collaboration. She included a written task requiring students to jot down what they did not know before and what they now knew after each collaborative activity. Such a continuous approach appears more promising because students have more opportunities to reflect on and evaluate the benefits of collaborative learning throughout the semester. At the same time, Teacher B could also adjust the design of collaboration activities based on the feedback.

Regarding resource support (Theme 2.3), the only consideration is to balance the extent of hints and guidance provided to the students, as students may potentially become overly reliant on hints and fail to develop independent problem-solving skills (Koedinger & Aleven, 2007). With the support of the discussion (Theme 2.4), it is essential to consider this approach's generalisability and potential drawbacks critically. While the designated leader and discussion structure can benefit some students, they may inadvertently suppress the natural development of leadership and negotiation skills among the entire group. Rotating the role of the leader could mitigate this limitation to some extent, but further exploration is needed to evaluate the long-term effects on students' collaborative skills beyond a single semester: for example, by incorporating grading criteria to evaluate students' collaborative skills (Swan et al., 2006). Additionally, the effectiveness of language tips and phrases may vary depending on students' language proficiency levels and cultural backgrounds. While some international students in this study reported considering the language tips helpful, it is crucial to recognise that language challenges in collaborative activities extend beyond mere phrases. Cultural norms, communication styles and linguistic diversity must also be considered (Jonasson & Lauring, 2012).

The potential drawbacks of maintaining the same group members throughout the semester (Theme 2.5) should also be considered. Relying solely on familiar members to collaborate could possibly limit students' exposure to diverse perspectives from others (Nokes-Malach et al., 2015). Students also benefit from the exploration of different viewpoints and the opportunity to adapt to various approaches to collaborative learning. In this regard, the strategy of maintaining consistent group membership may hinder students' ability to adapt to different team dynamics and restrict their exposure to a wider range of perspectives and ideas (Hoever, et al., 2012). Furthermore, the reliance on social media platforms for ongoing communication and collaboration raises concerns about equity and accessibility. Not all students have access to or are comfortable using certain social-media platforms, potentially excluding them from important collaborative discussions and interactions (Sabah, 2023). It is important for teachers to consider alternative means of communication that are accessible to all students, ensuring that no one is left out or disadvantaged. Teachers may wish to consider these factors and be prepared to address them to ensure that students can achieve their learning goals.

How to Develop Independent Learning through Needs-Supportive Strategies

Some researchers (e.g., Hughes, 2001) have used *autonomous learning* interchangeably with *independent learning*. Moore (1973), however, differentiates the two terms by stating that independent learning refers to the system or situation in which students need to take charge of their learning, while autonomous learning refers to the ability and willingness to exercise self-directed learning. As such, when autonomous-supportive strategies are implemented, students' independent learning is facilitated, and their capability and desire to perform independent learning are also empowered, meeting their autonomy needs. Independent learning is a soft skill essential for the future workplace that might not be taught explicitly at school (Liebech-Lien & Sjølie, 2021); therefore, the needs-supportive strategies identified from this study offer important insights into how this capability can be developed in students during their online learning experience in ERT. Four autonomy-supportive strategies were identified in this study: fostering relevance (Theme 3.1), offering choices (Theme 3.2), providing timely feedback (Theme 3.3) and promoting self-reflective practice (Theme 3.4).

As in previous sections, the strategies identified were supported by previous studies. Providing learning activities relevant to personal goals, interests, future study, or career goals (Theme 3.1) can address the independent learning issues in online contexts (Blumenfeld et al., 2006; Hartnett, 2015) and motivate students to persevere even when learning becomes difficult (Rentroia-Bonito et al., 2006). Offering choices (Theme 3.2) has been dramatically advanced by the online learning context. Before ERT, students had limited autonomy over their learning (Chiu, 2021). The shift to online learning has greatly enhanced the possibility of offering students choices because of the better use of learning management systems (Azevedo et al., 2008; Dabbagh & Kitsantas, 2004; Kearney et al., 2020). Offering students a choice of 'how' to learn, such as through videos, readings, simulations or all three, as evident in this study, promotes student perception of choice and personalisation of their learning experience (Alamri et al., 2020; Hidi & Renninger, 2006). Similarly, giving students control over the ‘when’ of their asynchronous learning allows for individualised pacing, improving learning effectiveness and mutual respect and trust between teachers and students (Mayer & Moreno, 2010). While setting deadlines for critical learning activities is essential, so is providing students with autonomy over their learning pace (Sweller, 2012).

Feedback (Theme 3.3) is undoubtedly critical for independent learning. Previous studies have focused on teacher participation in providing ongoing feedback in discussion forums or timely responses to students’ email inquiries (e.g., Bekele, 2010; Shroff et al., 2008; Wang & Wu, 2008); this study explored automatic written and video feedback to quiz questions by teachers. Agreeing with the previous finding, the amount of feedback received by students can influence their further participation in asynchronous learning (Deci & Moller, 2005), which in turn can affect student self-regulation strategies and increase learner self-efficacy (Jang et al., 2010; Xie et al., 2006; Zepke et al., 2009).

Regarding students’ self-reflective practice (Theme 3.4), previous studies (e.g., van Velzen, 2014) found that students know about self-reflection because they have been informed about it but do not intentionally use it to improve their learning. The design of self-reflective practices by Teachers A and B implicitly agrees with this. Both set up specific tasks—Teacher A’s strengths and weaknesses evaluation and Teacher B’s confidence checklist—to document student reflection and, more importantly, to improve and assess learning (Zubizarreta, 2004).

Several considerations arose from the findings of this study. It notably suggested that relevance to personal interests and future careers or studies (Theme 3.1) could possibly be significant criteria. Some students, however, could have difficulties identifying their interests or future career goals (Reynolds & Constantine, 2007); the effectiveness of fostering relevance in this group of students could be undermined. Additionally, offering too many choices (Theme 3.2) may result in decision fatigue or analysis paralysis (Iyengar & Lepper, 2000; Scheibehenne et al., 2010). Self-paced learning may also promote procrastination or reduce learning motivation (Steel, 2007; Steel & König, 2006). One takeaway from this study's findings was setting up a deadline for asynchronous tasks. Students still had the freedom to choose when to complete them. If they fail to complete the task before the deadline, however, teachers can intervene to prevent disengagement from the subject. The scheduling of deadlines could be more critical for pathway students, who are generally recognised as lacking time-management skills (Baik et al., 2019; Morison & Cowley, 2017).

Regarding feedback for supporting independent learning, both teachers use multiple-choice quizzes to evaluate students' understanding of the concept. Multiple-choice questions to assess student understanding of knowledge and concepts are widely accepted and appropriate in science (e.g., Karimi & Manteufel, 2020; Soeharto & Csapó, 2022). Some researchers (e.g., Cox et al., 2014, Haladyna et al., 2002; Shepard, 2000) argue that these assessments may not accurately measure students' understanding of complex concepts. They suggest that multiple-choice questions focus on factual recall rather than higher-order thinking skills and may not capture the depth of students' knowledge or their ability to apply knowledge in real-world contexts. However, other researchers (for example, Azer, 2003; Fuhrman, 1996) believe that carefully constructed multiple-choice questions can assess a wide range of skills and abilities, including higher-order thinking skills. Alternative assessment methods, such as open-ended questions, are also recommended to provide a more comprehensive and authentic assessment of students' understanding (Haladyna et al., 2002; Mislevy et al., 2003); teachers providing feedback promptly during students' asynchronous learning, however, will become a challenge.

Finally, while reflective practices provided opportunities for students to evaluate how well they had acquired knowledge and reflect on their progress, it is unclear whether they effectively improved their learning outcomes. For instance, using self-assessment tools, such as confidence checklists, may only sometimes provide an accurate reflection of students' progress or understanding of the material.

Teacher Self-Efficacy

This section focuses on how both teachers in this study developed their self-efficacy for online teaching during the first two semesters of ERT. Drawing from Bandura's self-efficacy framework, the present study categorised teacher self-efficacy development according to four sources: mastery experience, vicarious experience, verbal persuasion and emotional state.

Teachers' Self-Perception of Their Self-Efficacy Level in Online Teaching. Both teachers in this study expressed that their self-efficacy for online teaching increased significantly when they had more online teaching experience, in line with the findings from previous research (e.g., Lee & Tsai, 2010; Richter & Idleman, 2017). This finding, however, contradicts a study conducted during the first semester of ERT by Ma et al. (2021), who found that teacher self-efficacy levels at the end of a semester during China's COVID-19 school lockdown did not increase significantly.

Several reasons can account for the difference. The timing of evaluating teacher self-efficacy could be the reason behind the disparity between the current study and Ma et al.'s study. According to Bandura (1977), self-efficacy is developed when participants can evaluate their success. Teachers in Ma et al.'s (2021) study may not be able to see their students' academic results and evaluation feedback until the end of the first semester. Without such evidence, teachers in Ma et al.'s (2021) study may be unable to accurately assess their students' online instruction self-efficacy. In the current research conducted during the second semester of ERT, teachers observed their students' academic performance and success in using technology by designing and completing online courses in the first semester. Furthermore, teachers in the second semester have more mastery experiences in online teaching and more opportunities for vicarious experience and verbal persuasion. It should also be noted that the two teacher participants in the current study were 'exemplary' in their teaching. These factors can account for the teachers in the present study having a more positive sense of self-efficacy to engage students in online learning.

Mastery Experience. In line with previous studies (e.g., Hemmings, 2015; Leonardo et al., 2019), teachers in this study considered mastery experiences to be the main contributor to their growth in self-efficacy. There are several reasons for this. First, both teachers in this study had prior experience using online technologies. In particular, Teacher A was awarded the Technology Innovation Prize, indicating her advocacy for incorporating technology into her teaching before the ERT era. Technological challenges tend to affect teachers only before they become acquainted with the technologies (Lee & Tsai, 2010). While the use of online technology does not necessarily equate to effective online teaching, it is recognised that proficiency in online technology can facilitate the transition to online teaching. Therefore, teachers with prior experience and competence in online technology may be better positioned to acquire the skills and knowledge necessary for effective online teaching. Once they have mastered using various appropriate apps, they can focus on how these technologies can be used in their instructions to promote motivation and engagement in online learning.

Second, the mastery experience of delivering both asynchronous and synchronous online learning modes could contribute to a greater sense of self-efficacy. In the current study, both participating teachers delivered both types of teaching, which exposed them to different technologies and strategies for motivating and engaging students. In contrast, during ERT, many teachers focused on delivering synchronous teaching (e.g., Sumardi & Nugrahani, 2021), while some (e.g., Ma et al., 2021) only delivered asynchronous teaching but not both. As a result, both teachers in the current study who delivered perceived a higher level of contribution from mastery experience to their development of self-efficacy.

Third, when the teachers prepared for the asynchronous learning materials, they were heavily involved in designing such materials (e.g., Theme 1.1: chunking and checkpoints) and pedagogy (e.g., Theme 1.4: kinaesthetic activity). More importantly, both teachers in this study could use analytics in the learning management system to monitor student progress and performance in asynchronous learning. Therefore, when students completed asynchronous online activities and provided good feedback about the learning activities, teachers saw direct evidence of their effectiveness in creating an engaging learning experience. Such evidence directly translated into teachers' confidence and capability in online learning. These findings have further practical implications for preparing teachers to build self-efficacy in online teaching.

Vicarious Experience. Previous research has suggested that vicarious experience is less significant than the other three sources in building teacher self-efficacy (e.g., Ma et al., 2021). Some vicarious experience-specific studies (e.g., El-Abd & Chaaban, 2021) would even urge more mastery experiences to promote teacher self-efficacy. The present qualitative study could not evaluate the extent to which the source contributes to self-efficacy; it does, however, reveal three implications for vicarious experience.

First, it is likely that 'exemplary' teachers could make most use of vicarious experience, learning from others as to what works and what doesn't. Second, the degree of relevance in the context could be another factor. Teachers who witnessed how their colleagues navigated the unique challenges and demands of teaching specific subjects allowed the observing teachers to better identify with them and made the observed experiences more relatable, meaningful, and actionable (Martin, 2008). Third, practice-based professional development is critical to vicarious experience because it focuses on real-world classroom scenarios. Such an approach allows teachers to apply new strategies and techniques directly to their teaching practice. This relevance makes the learning experience more practical and applicable to their daily work (Cayirdag, 2017). The above factors have contributed to a stronger teachers' belief in their abilities to engage students in online learning.

Verbal Persuasion. Previous studies have suggested that verbal persuasion comes mainly from students (e.g., Hsu et al., 2021; Webb & LoFaro, 2020). As this study found, however, the effect of verbal persuasion from students appeared to be diminished in an online teaching context. This could be due to the various limitations of online learning, such as teachers not teaching in face-to-face classrooms, students' disabling their videos and teachers being unable to monitor all breakout rooms. Teachers could not receive direct and immediate non-verbal communication on their teaching from students during the semester.

The present study offers new insight into who, in addition to students, influences teachers' self-efficacy via verbal persuasion during ERT. This study showed that positive feedback from credible members who appear to be credible to have a positive influence on the development of teacher self-efficacy in online teaching. According to Bandura (1997), credibility is an important factor that increases the effect of verbal persuasion on self-efficacy. The feedback from these family members in Teacher A's case was deemed to be credible because they were interested in the subject matter, and Teacher B's colleagues encountered similar challenges posed by the sudden shift to online learning. Therefore, it is invaluable for teachers to share their online teaching design with others perceived by the teachers as credible, if possible.

Positive Emotions. The crucial role of teachers' positive emotions in raising their self-efficacy was a noteworthy finding from this study. While positive emotions alone may not directly enhance self-efficacy beliefs, according to Bandura (1997), the results suggest that, when positive emotions are coupled with other sources, such as mastery experience, they can contribute to a positive change in self-efficacy beliefs. For instance, both teachers in this study were able to remain positive and connect their passion for meeting the needs of students in the online environment. Both teachers invested time and effort in revamping their teaching materials, leading to more meaningful mastery experiences (e.g., Themes 1.1–3.4). Such mastery experience, in turn, further promotes their positive emotions and sense of self-efficacy in online learning. Therefore, emotional states appear to mediate between other sources of self-efficacy (e.g., mastery experience) and the development of online teaching self-efficacy. The more important role of emotional states than other sources was also reported in recent studies into teacher self-efficacy (e.g. Burić et al., 2020; van Rooij et al., 2019).

This finding also has practical implications for placing more emphasis on the emotional aspects of teachers for self-efficacy development.

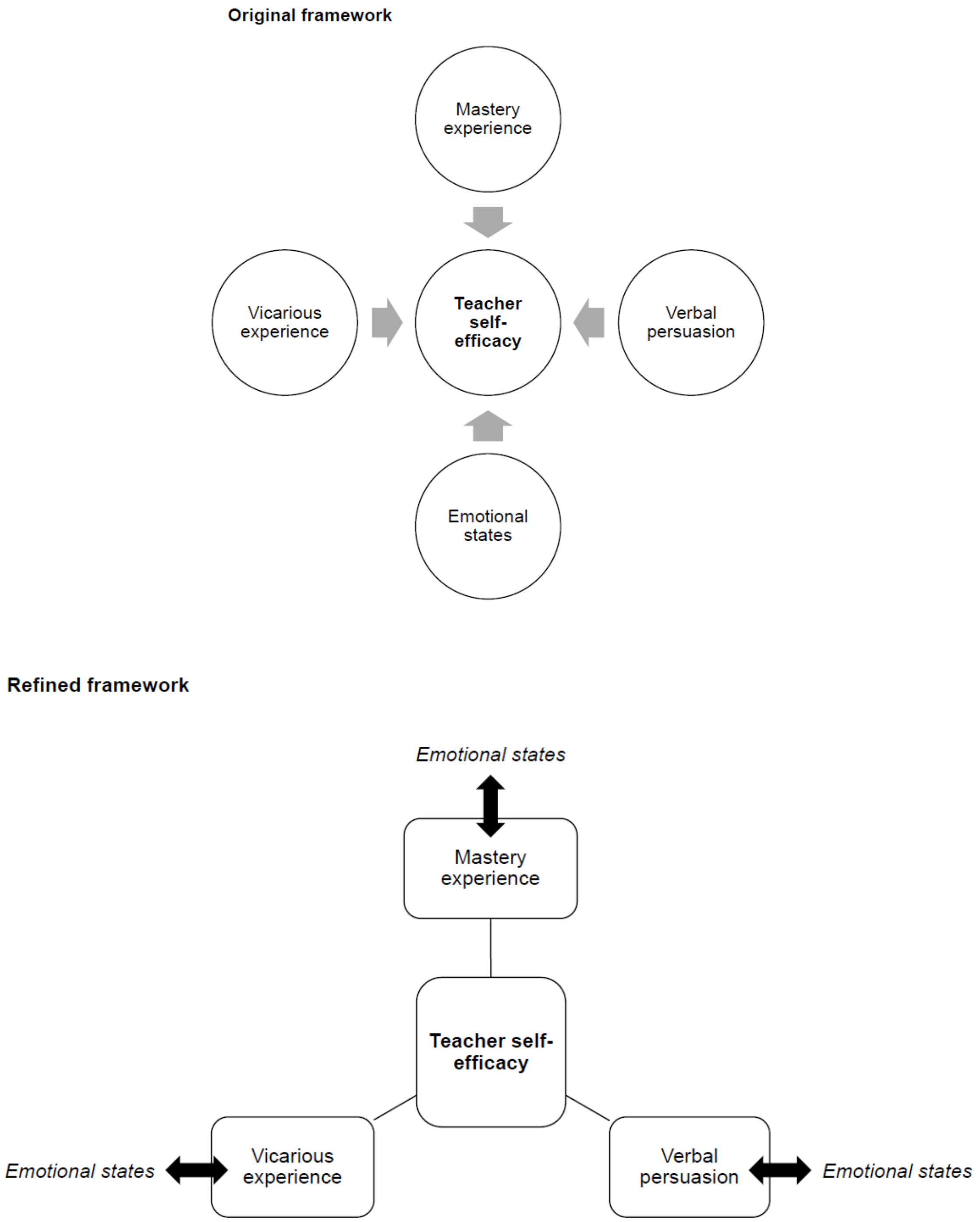
Theoretical Implications

Deci and Ryan's self-determination theory (SDT) and Bandura's self-efficacy theory informed the study's overall design. This study highlights the value of exploring self-determination and self-efficacy together. SDT is an analytical and explanatory framework providing valuable insights for designing strategies that address the challenges of online learning by satisfying students' psychological needs. Analysing self-efficacy sources enables researchers to understand the critical factors that enhance their capability and confidence in implementing needs-supportive strategies. Therefore, SDT analysis shows the resulting teacher actions, and self-efficacy analysis explains how teachers gain such capability and confidence.

Another theoretical contribution of this study is a refined framework for the source of teacher self-efficacy. Bandura's self-efficacy theory suggests teachers develop their self-efficacy through four sources: mastery experience, various experiences, verbal persuasion and emotional state. The findings of this study highlight the vital role of emotional state. The findings also reveal that emotional states could have a critical influence on other sources. In other words, positive emotional states may act as a pre-requisite for meaningful mastery experiences or other sources (see Figure 5.1). Positive emotions could be the foundation needed for all other sources to occur meaningfully, meaning that the extent of positive emotion a teacher possesses could affect the teacher's mastery experience, vicarious experience or verbal persuasion and, in turn, their ability to build their self-efficacy. At the same time, these sources would further contribute to a greater sense of positive emotion. As presented in Figure 5.1, the refined framework highlights the pre-requisite and mediating role of emotional state and other sources in teacher self-efficacy development.

Figure 5.1

Original and Refined Framework of Teacher Self-Efficacy Sources



The second theoretical contribution provides valuable insights into addressing specific challenges in online learning through three needs-supportive strategies. The study identified that a combination of 11 competency-supportive strategies, six relatedness-supportive strategies and 11 autonomy-supportive strategies effectively addresses the challenge of sustaining concentration in online learning. These results indicate that different needs-supportive strategies possess varying strengths, and their applicability may vary depending on the specific context. Notably, the study emphasises that the nature of the learning environment and the educational level of students, as exemplified by the challenges faced by university pathway students in this research, influence the choice of appropriate needs-supportive strategies to enhance student engagement. This observation recognises the diversity of students' psychological needs across educational sectors and learning environments.

Practical Implications

The primary objective of this study is to address a critical gap identified in previous research, which highlighted the widespread challenge of teachers struggling to effectively engage students in online learning during Emergency Remote Teaching (ERT). Building upon this pressing issue, our research endeavors to shed light on the practical-related aspects that contribute to teacher effectiveness in online teaching. The findings highlight the pivotal role of tailored professional development initiatives that can support the development of teacher self-efficacy and needs-supportive strategies. This study suggests the urgency of prioritising these aspects within educational frameworks, emphasising that teachers and professional development programs focusing on these elements are instrumental in fostering meaningful engagement and effective learning experiences for students in the online environment.

Teacher Self-Efficacy-Related Implications

There are four practical implications stemming from the findings related to teacher self-efficacy. First, the study highlights the significance of mastery experiences in shaping teachers' self-efficacy. Teachers with more opportunities to design and complete online courses in the first semester reported a more positive sense of self-efficacy in engaging students in online learning. The empirical implication also suggests that exposing teachers to both asynchronous and synchronous online learning modes can contribute to a greater sense of self-efficacy. Professional-development activities could include opportunities for teachers to explore and practice different teaching modalities, technologies and strategies (Hemmings, 2015; Leonardo et al., 2019). By gaining experience in delivering both asynchronous and synchronous instruction and monitoring online learning performance, teachers can expand their repertoire of online teaching methods and feel more confident in their ability to engage students effectively.

Another practical implication is the importance of incorporating emotional aspects into professional-development activities for teachers. The findings highlight the crucial role of positive emotions in enhancing teachers' self-efficacy. It suggests that, when teachers experience positive emotions in combination with mastery experience, vicarious experience and verbal persuasion, their self-efficacy beliefs are positively influenced. Therefore, supporting teachers in cultivating positive emotional experiences can contribute to developing their self-efficacy in online teaching. For example, the institution can provide opportunities for teachers to reflect on their achievements and successes, foster a supportive and encouraging environment and offer resources for managing stress and maintaining a positive mindset. By addressing teachers' emotional well-being and providing support in regulating their emotional state, institutions can create a conducive environment for the development of self-efficacy beliefs in online teaching.

Moreover, while teachers recognise the importance of practice-focused professional development for building self-efficacy, it is critical to emphasise the importance of theory-based professional development activities. It would be beneficial for the College to explore teachers' beliefs about education and pedagogical theories before introducing teachers to established theories, models, and frameworks. The activities could potentially promote teachers' interest in gaining a deeper understanding of the underlying principles and concepts guiding their practice (Postholm, 2012). Such understanding improves their capacity to think critically, analyse situations, and make well-informed pedagogical decisions in their teaching (Adey, 2007).

Furthermore, while the effect of verbal persuasion from students may be limited in the online teaching context due to various limitations, such as the inability to receive direct and timely feedback, this study highlights the positive influence of feedback from family members and teaching colleagues. Institutions can encourage teachers to engage in reflective practices and seek feedback from others who are interested in the subject matter. Family members can provide a unique perspective and offer encouragement and support to teachers in their online teaching journey. Regarding colleagues, it is important for institutions and professional-development programmes to encourage and facilitate a supportive feedback culture among teachers. This can involve creating platforms—for example, Microsoft Teams channels—where teachers can conveniently share their teaching experiences and receive constructive feedback from their colleagues. Peer observations and feedback sessions can be organised to allow teachers to reflect on their online teaching practices and gain insights from their peers. Furthermore, institutions can promote collaboration and support networks among teachers across different institutions. By fostering connections and sharing experiences with colleagues who have encountered similar challenges in online teaching, teachers can receive valuable feedback and encouragement that contributes to their self-efficacy. Online forums, communities of practice (Wenger, 1998) or professional learning networks can be established to facilitate these interactions and support teachers in their self-efficacy development.

Needs-Supportive Strategies-Related Implications

Several practical implications can be drawn from the finding related to needs-supportive strategies. One practical implication is to implement needs-supportive strategies that are mode-agnostic and applicable to both face-to-face and online teaching contexts. These mode-agnostic needs-supportive strategies not only are part of the resilient pedagogy but also meet psychological needs in students. As such, educational institutions and teachers might consider prioritising the development and implementation of needs-supportive strategies.

First of all, professional-development programmes could provide teachers with a comprehensive understanding of SDT. The development programme might also consider the interdependence of needs-supportive strategies and self-efficacy beliefs in designing a supportive online learning environment. The 13 identified needs-supportive strategies could be used as a resource for professional-development programmes that help other teachers consider how to implement these strategies in practice. It is important to note that, as online learning during ERT has shifted teachers' and students' reliance on synchronous contact to the equally crucial asynchronous environment, teachers must implement needs-supportive teaching and instructional design strategies in the asynchronous space. As revealed by this study, many strategies from the pre-ERT era were adapted and modified. As a result, educators might reflect on their current practices to see how they can meet students' psychological needs and how such practices can be adapted to online learning. When existing practices fail to meet particular challenges, novel strategies, such as those identified in this study, are required to support students. These strategies may benefit student learning not only during, but also possibly after, ERT.

At the same time, teachers need to understand that different needs-supportive strategies have varying strengths and applicability depending on the specific challenges and learning environment. Teachers can thus be encouraged to explore and select appropriate strategies based on the nature of the learning challenge and environment encountered by students.

By connecting teacher practices and student psychological needs, educators can clearly understand how to develop teaching practices that will help students overcome challenges in online learning. The following subsection offers practical implications for individual needs-supportive strategies.

Theme 1.1: Chunking and Checkpoints. Teachers could actively employ chunking techniques when designing and presenting online learning materials. By dividing information into smaller, coherent chunks, students can better process and retain the content. Teachers may also consider incorporating checkpoint mechanisms, such as quiz questions or formative assessments, within each chunk of content. These checkpoints serve multiple purposes: visually signalling progress and completion, providing students with opportunities to demonstrate their understanding and promoting engagement and concentration throughout the online learning experience. This strategy is especially crucial for pathway students, who are novice learners and may struggle with information overload in online environments.

Theme 1.2: Deliberate Rehearsal of Concepts. Teachers could create a supportive feedback culture by establishing norms and guidelines for constructive feedback, addressing power dynamics and encouraging active participation. Additionally, teachers may wish to focus on developing students' feedback skills through explicit instruction, modelling examples and providing opportunities for practice and refinement.

Theme 1.3: Information Reorganisation. Teachers could carefully assess the complexity of the materials, the cognitive abilities of the learners and the instructional context to determine the appropriate level of integration. They may also ensure that the integration is coherent and meaningful, avoiding oversimplification or the loss of essential details. As planning and design efforts may be required, teachers could consider the potential time and resources required.

Theme 1.4: Kinaesthetic Activities. While kinaesthetic activities may be beneficial for topics that allow for hands-on exploration, they may be less effective for abstract or theoretical concepts that require more conceptual understanding or symbolic representation. It is therefore important for teachers to assess the suitability of kinaesthetic learning activities based on the subject matter and learning goals. In such cases, alternative strategies, such as simulations, may be more appropriate (Almasri, 2022).

Theme 2.1: Online Collaborative Tool Familiarisation. Teachers might consider providing a clear and compelling explanation of the benefits of collaborative learning to students. By explicitly highlighting its advantages, such as enhanced learning outcomes, improved problem-solving skills and increased engagement, teachers can help students understand the value of collaborative learning and overcome any initial negative attitudes or resistance.

Theme 2.2: Promoting the Benefits of Collaborative Learning. Teachers could recognise the significance of digital literacy and the need for students to understand online collaborative tools. The findings from this study suggest that teachers may wish to provide explicit instruction on these tools, offering step-by-step guidance and hands-on practice to develop students' digital communication skills. Importantly, teachers can also assess the effectiveness of their instruction, evaluating students' proficiency with the tools and their application in collaborative activities and seeking feedback to make necessary adjustments and support ongoing skill development.

Theme 2.3: Resources for a Fruitful Collaboration. Teachers could strive to make the tasks authentic and problem-solving in nature to enhance students' motivation and agency. By working with real-world relevance and challenging problems, students are more likely to engage actively in the collaborative process. Teachers, however, could also be cautious about providing excessive prompts and hints, as it may hinder the development of independent problem-solving skills. It is important to strike a balance between providing support and fostering students' autonomy.

Theme 2.4: Discussion Support for Effective Collaboration. It is important to foster a sense of collective responsibility and ensure that students recognise the value of working together as a team. Teachers can assign roles to students to promote individual contributions and address workload imbalances. While assigning roles can address concerns about equitable workloads, teachers could reflect on whether this approach unintentionally undermines the collective nature of collaboration. Teachers can encourage open discussions and promote a collaborative mindset to ensure that students understand the importance of collective problem-solving. Additionally, providing templates, scaffolds and language support can enhance student confidence and facilitate their engagement in collaborative tasks. Teachers could, however, evaluate the effectiveness of the support strategies provided during collaborative tasks. This assessment can include observing students' engagement, monitoring their reliance on support resources and seeking feedback from students. By assessing the effect of support strategies, teachers can make informed decisions about adjusting their approach and promoting students' independent problem-solving skills while still providing the necessary guidance.

Theme 2.5: Maintaining the Same Group Members Throughout the Semester. Teachers can promote effective collaboration by keeping the same group members in each collaborative activity throughout the semester when delivering the course online. Allowing students to form their own groups can also increase motivation and engagement, which have been shown to foster enduring and productive collaboration. Teachers may wish to pay attention to the potential drawbacks to this strategy, such as students' limited exposure to diverse perspectives and the need to address group dynamics and individual differences.

Theme 3.1: Fostering Relevance. Teachers could strive to make course content personally significant to students by connecting it to their daily lives and experiences. Incorporating activities that relate to students' interests and goals can increase their engagement and concentration. Teachers may also wish to emphasise the utility value of learning activities by highlighting their relevance to students' future academic and professional aspirations. By demonstrating how the course content aligns with their goals, teachers can motivate students to persevere and maintain concentration even when faced with challenges. Teachers could pay attention to the limitations and challenges associated with fostering relevance. It may be challenging to identify and connect course content to the diverse personal goals and interests of each student. Teachers could also be aware that some students may not be clear about their personal goals or interests or may not immediately see the relevance of certain content.

Theme 3.2: Offering Choices. Teachers can promote student autonomy and engagement by offering choices of learning methods and allowing students to control the timing and pace of their asynchronous learning activities. Providing options like videos, readings and simulations enhances personalisation and autonomy, creating a supportive learning environment. Teachers may pay attention to students' preferences and guide them to make effective choices aligned with their goals. While giving autonomy, teachers may also establish clear deadlines and monitor progress to prevent disengagement and address challenges. Teachers could also be aware that overwhelming students with too many choices or promoting procrastination (Spinney & Kerr, 2023). Striking a balance between autonomy and support is the key to this strategy's success.

Theme 3.3: Providing Timely Feedback. In asynchronous learning, teachers could prioritise the provision of timely and supportive feedback, in both written and video forms, or available formats based on the learning management system, to promote independent and autonomous learning. While multiple-choice quizzes are commonly used for assessment, teachers may wish to consider the benefits of alternative assessment methods, such as open-ended questions, to assess students' understanding comprehensively in the asynchronous learning environment (Nyachwaya et al., 2011).

Theme 3.4: Promoting Self-Reflective Practice. Teachers could design self-assessment and reflection activities to engage students in assessing their learning progress. Activities like assessing strengths and weaknesses and using self-assessment tools can easily be conducted in an online environment and provide opportunities for students to reflect on their learning.

View on which strategies might have been most and least impactful. Several factors come into consideration when considering the potential impact of the study's identified needs-supportive practices. Strategies that address all three psychological needs - autonomy, competence, and relatedness - such as deliberate concept rehearsal (Theme 1.2), familiarisation with online collaboration tools (Theme 2.1), promoting the benefits of collaborative learning (Theme 2.2), discussion support for effective collaboration (Theme 2.4), and providing options (Theme 3.2), are likely to be the most impactful. According to the study's findings, these practices enabled students to take ownership of their learning, increased their sense of competence, and fostered meaningful connections with peers, teachers, and curriculum.

While kinaesthetic activities (Theme 1.4), such as enzyme experiments or body joint movement activities, provide valuable opportunities for engagement and interaction, their effectiveness may vary depending on factors such as teacher expertise and student preferences. Enzyme experiments, for example, may require specialised materials not readily available in a kitchen or supermarket, making them impractical for some students. Similarly, body joint movement activities may necessitate a significant amount of space in front of a camera, which not all students may have. The success of these strategies depends on teachers' ability to effectively design and facilitate kinaesthetic experiences, as well as students' willingness to engage in hands-on learning activities. Furthermore, contextual factors such as resource availability and instructional time can have an impact on the feasibility and effectiveness of resource-intensive classroom strategies. Similarly, having the same group members throughout the semester (Theme 2.5) may not always be effective because it limits students' opportunities for diverse perspectives and collaboration, especially in situations where group dynamics or interpersonal conflicts may arise.

As a result, the effectiveness of each strategy is determined by a complex interplay of factors, including teachers' ability to implement such activities, implementation feasibility, and responsiveness to students' needs and preferences. While certain strategies may show promise for increasing student engagement and learning outcomes, readers should interpret these findings with caution and take into account the student population's unique needs as well as the characteristics of their own instructional context.

Limitations and Future Research

This study acknowledges seven main limitations. Accompanying these limitations are recommendations for future studies.

Generalisability – context

The present study focuses on a specific context: online learning during the COVID-19 pandemic and science in an Australian university pathway programme. The findings may not be fully generalisable or applicable to other educational settings or student populations. Comparative studies across different educational contexts, such as different grade levels, subjects and learning environments, can be conducted to examine the generalisability and transferability of the identified strategies and critical factors behind the development of teacher self-efficacy.

Generalisability – ‘exemplary’ teachers

The generalisability of findings based on these 'exemplary' teachers to the wider teaching population merits careful consideration. This study intentionally focused on 'exemplary' teachers, aiming to acknowledge the significance of their expertise and offer unique perspectives on effective strategies in the challenging context of Emergency Remote Teaching (ERT). While these teachers were intentionally chosen for their exceptional qualities, it isimportant to recognise that they may possess specific experiences or qualities that differentiate them from other educators. Equally essential is the acknowledgment that individual contexts, institutional resources, and varied teaching scenarios which can all significantly impact the adaptability of strategies. Despite the uniqueness of 'exemplary' teachers, it's strongly believed that the principles and strategies unveiled in this study offer valuable lessons for all educators, potentially benefiting a broader audience. The emphasis on cultivating teacher self-efficacy and addressing students' psychological needs aligns with fundamental teaching principles that hold universal relevance. By acknowledging both the strengths and limitations of the approach adopted in this study, the goal of this study was not to present a one-size-fits-all solution but rather to contribute valuable considerations and principles adaptable to diverse educational contexts. Therefore, the implications of this study could potentially extend beyond the specific cohort of 'exemplary' teachers, laying a foundation for further exploration and adaptation within various teaching environments.

Subjectivity and Bias

Participants in the current study were asked to self-report their self-efficacy and practice for two reasons. First, it is difficult for me as the researcher to see the intention behind the instructional design and teaching practices when it comes to strategies (Reeve et al., 2019). Second, and relatedly, it is acknowledged that teaching experiences and personal insights are multi-layered, influenced by various factors and therefore not easily expressed or formalised (Bobis et al., 2016). Knowledge that is difficult to articulate or transfer to others through verbal or written communication is known as *tacit knowledge* (Gascoigne & Thornton, 2014). In the current study, the four sources of self-efficacy conveniently provided teachers with a framework as well as language to express their tacit knowledge (Rahman et al., 2018).

While self-reporting is appropriate for exploring self-efficacy and needs-supportive strategies, it does have limitations. The main weakness is that self-reporting may affect the credibility of participant responses because participants may have a social desirability bias, defined as “the desire to edit a response before communicating it to a researcher in order to make the responder look good” (Gonyea, 2005, p. 82). Because meaningful insights can only be gained from participants’ honest responses (Miner-Romanoff, 2012), the current study’s findings should be interpreted with caution. The present study used other data-collection tools, such as lesson observation and artefact collection, to help verify teachers’ self-accounts. Future studies could extend the study period longitudinally and cross-sectionally to include more classes to be observed, enhancing the credibility of the current findings.

Furthermore, giving teachers the freedom to choose which video-recorded lessons to share or withhold introduced a potential challenge in the form of selective presentation bias. When exercising this option, teachers may be tempted to highlight lessons in which they are most confident, or that align with their desired professional image. This deliberate selection may result in the omission of other instructional practices that are equally important. As a result, the observed lessons may not provide an accurate representation of the teacher's instructional strategies. As a researcher, I am aware of this potential bias and, as such, considered lesson observation as an additional data collection tool to validate teacher instructional practices mentioned in interviews.

Teachers participating in both pilot and main study

It is also important to note that the inclusion of the same teachers in both the pilot and main studies presents both advantages and limitations to this research. On the positive side, continuity with the same participants offers the potential for more comprehensive data continuity. This continuity allows researchers to examine deeply into themes, potentially enhancing the overall quality and depth of the study's findings (Holloway, 1997). Furthermore, the ongoing engagement with participants across both phases fosters a stronger researcher-participant relationship (Janghorban et al., 2014). This relationship positively impacts data collection, encourages participants to share more openly, and enriches the insights gathered.

However, the continued involvement of participants across both phases introduces certain limitations. Prolonged participation might lead to participant fatigue or undue burden (Teijlingen & Hundley, 2001). To safeguard participant well-being and maintain voluntary participation, measures such as informed consent, regular check-ins, and spacing out the study phases were already implemented. Still, the involvement of the same participants in both phases could lead to familiarity bias, where participants become familiar with the study's objectives and methods, potentially influencing their responses or behaviors in the main study. This familiarity might compromise the authenticity of their reactions (Crossman, 2007). While such familiarity might deepen insights, it could also introduce biases based on their prior involvement (Ismail, Kinchin & Edwards, 2018). Therefore, these limitations merit careful consideration.

Longer-Term Effects

The present study focused on the immediate beliefs, strategies and experiences of teachers in the online learning environment during the second semester of ERT. The long-term effects of the implemented strategies and interventions, however, were not examined. Longitudinal studies that track the effects of implemented practices and strategies over an extended period (e.g., more than one year) can be conducted in the future. This will provide insights into the sustainability and long-term effect of these interventions on student engagement (Salmela-Aro et al., 2021).

Methodological Limitations

The current study relied on interviews as its primary data-collection strategy. Data from lesson observations and artefacts were used to validate teachers' accounts of their teaching practices and self-efficacy. Interviews allowed for the collection of a large amount of data to understand detailed information about teacher practices and self-efficacy (Yurekli et al., 2020). The qualitative interviews used in this study, however, have some limitations. As expected, data collection, transcript preparation and data analysis are time- and energy-consuming processes (Eftenaru, 2022). The data-analysis process, which is inherent in all studies involving interviews, also necessitates a high degree of interpretation by the researcher (Tongco, 2007). These limitations have been reduced; for example, the present study used standardised analytical frameworks that clearly define the codes with meanings and examples. Future research using mixed methods would be recommended. Quantitative methods, such as surveys, would help quantify teachers' levels of self-efficacy in online teaching and measure the causal relationship among teacher practices, teacher self-efficacy and the extent of student engagement. The study's scope can also be expanded by including more teacher participants and classes from different science subjects. Future research can incorporate stimulus tasks, such as scenario-based interviews (Adler & Patahuddin, 2012)—e.g., different online teaching scenarios, self-efficacy sources or teacher practices)—to help teachers articulate and express their thoughts and feelings about science teaching in the online environment. The study could compare and triangulate teacher self-efficacy, teacher needs-supportive practices and student engagement in university pathway classrooms by incorporating multiple data-collection tools into the mixed method. The mixed method could thus potentially enlighten researchers on how to effectively promote student motivation and engagement in online learning.

The present qualitative study provides in-depth insight into the strategies implemented by teachers. Future quantitative studies can explore the individual and collective effects of needs-supportive strategies in the same institutional context. Quantitative studies provide empirical evidence to inform evidence-based decision-making. The findings can inform teachers and other stakeholders, such as instructional designers, about the effect of these strategies on student motivation, participation and overall learning outcomes. Thus, these results can guide stakeholders in making informed choices about the adoption and implementation of appropriate needs-supportive strategies in online classrooms to achieve the desired goal of online learning experiences for students.

In addition to providing guidance for effective online teaching, the current study's needs-supportive strategies can be used in future intervention studies. Needs-supportive strategies in the form of an intervention tool can play a role in initiating conceptual and behavioural change in teacher practice. Experimental studies to test the effectiveness of specific interventions or strategies identified in the present study can be conducted in the future (Quested et al., 2021). This will allow for a more rigorous evaluation of the causal relationships between interventions and outcomes.

Understanding the Use of Needs-Supportive Strategies in Science Classrooms

Similar studies can be conducted in different subject areas and with different types of teachers to explore whether the limited use of relatedness-supportive strategies is a common issue in remote teaching or is specific to science teachers. The factors that hinder the development of relatedness-supportive strategies in online science classrooms can also be investigated. For example, how the limited use of relatedness-supportive strategies affects students' learning outcomes, teacher-student relationships and student engagement can be explored. How teacher–student interactions in synchronous online learning can be used to support relatedness in remote teaching can be further explored. This could include investigating the role of technology and the effectiveness of different approaches to synchronous teaching in supporting relatedness in remote learning environments. Overall, further research in this area could potentially help identify effective strategies for building relationships and promoting relatedness in remote learning environments, which can ultimately improve students' learning outcomes and well-being.

Conclusion

This study arose from concerns about poor engagement in online learning during ERT and the disappointing attrition in the science courses at the Australian university pathway programmes. The overarching aim of this study was to understand how student engagement can be improved in online learning during ERT. The research presented in this thesis demonstrates how needs-supportive strategies can support pathway students in online learning and how teachers gain self-efficacy for implementing these strategies. The findings of this study indicate that teachers' needs-supportive practices have a notable effect on addressing online learning challenges and, as a result, student engagement online. The findings also illustrate that teachers must pay attention to their emotions and existing practice to build their self-efficacy for online teaching. As such, these findings have important implications for tertiary teachers' ongoing professional development to promote teacher self-efficacy and needs-supportive practices, which can positively influence student engagement in online learning.

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Appendix

Appendix 1.1 Information sheet – Teacher participants

Student engagement in first-year university biology: course tutors'erspectives on their approaches to support engagement

Information Sheet for Course Tutors

This leaflet tells you about my research. I very much hope that you would like to take part. This information sheet willtry and answer any questions you might have about the project, but please don't hesitate to contact me if there is anything else you would like to know.

Why is this research being done?
Improving student engagement in science, particularly during the critical transitional first-year university, is an important issue in education. To achieve this, it is necessary to understand what can be done to support student engagement. One of which is to understand first-year university course tutors' perspectives on their approaches to promote student engagement, as this study aims to. This study will be conducted at UTS Insearch and focus on onesubject area within the science discipline – biology. The results of the study will inform previous research on biology teaching; and generate implications for other first-year biology tutors to promote student engagement.

Who is conducting the research?
Justin Kit-yan Chu, a Doctor of Education (EdD) student in the Curriculum, Pedagogy and Assessment Department atthe University College London, Institute of Education (UCL IOE) under the supervision of Dr Jennie Golding. In this study, I am hoping to find out your perspectives on the approaches you use to support student engagement in biology. I will be conducting this research in the role of a researcher, not as a teaching staff member at UTS Insearch. I will restrain from entering into discussions about individual students or to offer personal opinion.

Why am I being invited to take part?
Participants are teachers of any introductory biology subjects at UTS: INSEARCH. Your views and experience inteaching the subject will provide valuable feedback regarding student engagement in biology.

What will happen if I choose to take part?
The research will take place from 15th November 2019 to 31st December 2020. I would envisage the followingcommitment and activities (see the Figure on the next page).

Before the start of Stage 1, please complete the Course Tutor consent forms.

In Stage 1, I would conduct initial face to face interview with you in a meeting room at UTS: INSEARCH. The interview will take approximately 30-60 minutes and be audio recorded. All the data collected will be sent to the teacher for approval of the content.

You will first have opportunities to share your understanding of 'student engagement' by asking 'What do you understand by the term – student engagement?'. You will then be asked 'What approaches do you use to support student engagement in biology?'. Other questions aimed at eliciting further information about the teaching approaches include: 'Can you provide an example of this approach?', 'On what occasions, do you use this approach?', 'Can you share your rationale behind your choice and use of this approach?', 'What challenges do you encounter when you use the approach to promote student engagement in biology?'

Field notes recording events that cannot be recorded, such as your excitement towards certain teaching approacheswill be made. You are invited to bring along artefacts, such as lesson plans and lesson worksheets, that you think they are helpful in explaining the approaches you use.

In Stage 2, you are asked to send information sheets and consent forms to students whose tutorials are to be observed and video-recorded. Four or more biology tutorials are expected to be observed and video-recorded. Thereis a possibility of additional observations to be carried out until data saturated, a point where “no new information or themes are observed in the data" (Guest, Bunce, & Johnson, 2006, p. 59). Artefacts will also be collected for further analysis. Field notes will also be made.

In Stage 3, relevant segments of the video-recorded lessons, artefacts and field notes will be shown to the you and ask you about your perspectives on adopting those approaches to support engagement. The interview will be semi-structured, 30-60 minutes in duration and audio-recorded. I will endeavour to keep interviews as concise as possible: I appreciate your time is valuable.

Stage 1 - Initial Interview

Aim: To understand the approaches used by teachers to support student engagement in biology, and the rationale behind their choice.

Main data source: interview

Supporting data sources: artefacts and field notes

Duration: 30-60 minutes

Stage 2 - Lesson observation (two tutorial lessons)

Aim: To identify additional approaches used by teachers not mentioned in the initial interviews.

Main data source: video-recorded lesson

Supporting data sources: artefacts and field notes

Duration: 60 minutes

Stage 3 - Final Interview

Aim: Relevant segments of the video-recorded lessons, artefacts and field notes will be shown to participants to seek additional insights or evidence of approaches that support student engagement.

Main data source: interview

Supporting data sources: artefacts and fieldnotes

Duration: 30-60 minutes

Will anyone know I have been involved?
Any data obtained from you will be kept securely. Your identity will be anonymised by the use of a unique identifier. The data and overall results of the study will share with my supervisor only. The finding will be reported in my EdD thesis and a written summary will also be disseminated to you, with your identity anonymised. The results may also be presented at professional conferences and in research publications. Secure storage of digital data, including audio recording, video recording and transcripts will be kept in a password protected system for 10 years after the research; and to which only the researcher and the supervisor have the access. You will be welcome to see the transcripts of your interview when completed.

Do I have to take part?
It is entirely up to you whether or not you choose to take part. I do not anticipate that any problems would arise if you choose not to take part but would be pleased to talk with you at any stage about any aspect of the project.

There is clear evidence that professional talk with external knowledgeable others can develop teacher thinking about their work and also result in greater job satisfaction. We hope you would enjoy and further develop from participation.

You would also know that you are contributing to my understanding of how to support student engagement in biology at UTS Insearch. Promoting student engagement is a priority for you, me and the institute.

I hope that if you do choose to be involved then you will find it a valuable experience. You are free to withdraw from the study at any time before the end of the study period (i.e. December 2020) without reason and without any impact on you. If you decide to withdraw, any data collected from you will be destroyed.

Will you know about the research results?
You can see what I have written that involves you and your classroom, at any time on request. At the end of the research I will send you the key findings.

If you would like to be involved, please complete the following consent form and return to Justin Kit-yan Chu via kit.chu.16@ucl.ac.uk by 15th November 2019.

If you have any further questions before you decide whether to take part, you can reach me at kit.chu.16@ucl.ac.uk or my supervisor Dr Jennie Golding at j.golding@ucl.ac.uk.

This project has been reviewed and approved by the UCL IOE Research Ethics Committee Z6364106/2019/11/28.

Data Protection Privacy Notice

Notice:

The data controller for this project will be University College London (UCL). The UCL Data Protection Office provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk. UCL's Data Protection Officer is Lee Shailer and he can also be contacted at data-protection@ucl.ac.uk.

Your personal data will be processed for the purposes outlined in this notice. The legal basis that would be used to process your personal data will be the provision of your consent. You can provide your consent for the use of your personal data in this project by completing the consent form that has been provided to you.

Your personal data will be held for 10 years. We will anonymise or pseudonymise the personal data you provide, and will endeavour to minimise the processing of personal data wherever possible.

If you are concerned about how your personal data is being processed, please contact UCL in the first instance at data-protection@ucl.ac.uk. If you remain unsatisfied, you may wish to contact the Information Commissioner's

Thank you for reading this leaflet. The research is of great importance in providing information about teachers' perspectives on their approaches used to support student engagement in biology and we hope you will take part.

Yours sincerely,

Mr Justin Chu
UCL Institute of Education
kit.chu.16@ucl.ac.uk

Dr Jennie Golding
UCL Institute of Education
j.golding@ucl.ac.uk

Appendix 1.2 Information sheet – Dean of Studies

Institute of Education

Student engagement in first-year university biology: course tutors' perspectives on their approaches to support engagement

Information Sheet for Dean of Studies

This leaflet tells you about my research. I very much hope that you would like to take part. This information sheet will try and answer any questions you might have about the project, but please don't hesitate to contact me if there is anything else you would like to know.

Why is this research being done?
Improving student engagement in science, particularly during the critical transitional first-year university, is an important issue in education. To achieve this, it is necessary to understand what can be done to support student engagement. One of which is to understand first-year university course tutors' perspectives on their approaches to promote student engagement, as this study aims to. This study will be conducted at UTS Insearch and focus on one subject area within the science discipline – biology. The results of the study will inform previous research on biology teaching; and generate implications for other first-year biology teachers to promote student engagement.

Who is conducting the research?
Justin Kit-yan Chu, a Doctor of Education (EdD) student in the Curriculum, Pedagogy and Assessment Department at the University College London, Institute of Education (UCL IOE) under the supervision of Dr Jennie Golding. In this study, I am hoping to find out your perspectives on the approaches you use to support student engagement in biology. I will be conducting this research in the role of a researcher, not as a teaching staff member at UTS Insearch. I will restrain from entering into discussions about individual students or to offer personal opinion.

Why am I being invited to take part?
Participants are tutors of any introductory biology subjects at UTS: INSEARCH. Their views and experience in teaching the subject will provide valuable feedback regarding student engagement in biology.

What will happen if I choose to take part?
The research will take place from 15 November 2019 to 31 December 2020. I would envisage the following commitment and activities (see the Figure on the next page).

Before the start of Stage 1, please complete the Dean of Studies consent forms.

In Stage 1, I would conduct initial face to face interview with tutors in a meeting room at UTS: INSEARCH. The interview will take approximately 30-60 minutes and be audio recorded. All the data collected will be sent to the teacher for approval of the content.

Tutors will first have opportunities to share their understanding of 'student engagement' by asking 'What do you understand by the term – student engagement?'. Tutors will then be asked 'What approaches do you use to support student engagement in biology?'. Other questions aimed at eliciting further information about the teaching approaches include: 'Can you provide an example of this approach?', 'On what occasions, do you use this approach?', 'Can you share your rationale behind your choice and use of this approach?', 'What challenges do you encounter when you use the approach to promote student engagement in biology?'

Field notes recording events that cannot be recorded, such as the teacher's excitement towards certain teaching approaches will be made. Teachers are invited to bring along artefacts, such as lesson plans and lesson worksheets, that they think they are helpful in explaining the approaches they use.

In Stage 2, tutors are asked to send information sheets and consent forms to students whose tutorials are to be observed and video-recorded. Four or more biology tutorials are expected to be observed and video-recorded. There is a possibility of additional observations to be carried out until data saturated, a point where "no new information or themes are observed in the data" (Guest, Bunce, & Johnson, 2006, p. 59). Artefacts will also be collected for further analysis. Field notes will also be made.

In Stage 3, relevant segments of the video-recorded lessons, artefacts and field notes will be shown to the tutors and ask the tutors about his/her perspectives on adopting those approaches to support engagement. The interview will be semi-structured, 30-60 minutes in duration and audio-recorded. I will endeavour to keep interviews as concise as possible: I appreciate the tutor's time is valuable.

Stage 1 - Initial Interview

Aim: To understand the approaches used by teachers to support student engagement in biology, and the rationale behind their choice.

Main data source: interview

Supporting data sources: artefacts and field notes

Duration: 30-60 minutes

Stage 2 - Lesson observation (two tutorial lessons)

Aim: To identify additional approaches used by teachers not mentioned in the initial interviews.

Main data source: video-recorded lesson

Supporting data sources: artefacts and field notes

Duration: 60 minutes

Stage 3 - Final Interview

Aim: Relevant segments of the video-recorded lessons, artefacts and field notes will be shown to participants to seek additional insights or evidence of approaches that support student engagement.

Main data source: interview

Supporting data sources: artefacts and fieldnotes

Duration: 30-60 minutes

Will anyone know I have been involved?

Any data obtained from your tutors will be kept securely. Their identities will be anonymised by the use of a unique identifier. The data and overall results of the study will share with my supervisor only. The finding will be reported in my EdD thesis and a written summary will also be disseminated to you and the tutors, with the tutors' identities anonymised. The results may also be presented at professional conferences and in research publications. Secure storage of digital data, including audio recording, video recording and transcripts will be kept in a password protected system for 10 years after the research; and to which only the researcher and the supervisor have the access. Tutors will be welcome to see the transcripts of their interviews when completed.

Do I have to take part?

It is entirely up to you whether or not you choose to take part. I do not anticipate that any problems would arise if you choose not to take part but would be pleased to talk with you at any stage about any aspect of the project.

There is clear evidence that professional talk with external knowledgeable others can develop teacher thinking about their work and also result in greater job satisfaction. We hope the tutors would enjoy and further develop from participation. Your participation is contributing to my understanding of how to support student engagement in biology at UTS Insearch. Promoting student engagement is a priority for you, me and the institute.

I hope that if you do choose to be involved then you will find it a valuable experience. You are free to withdraw from the study at any time before the end of the study period (i.e. December 2020) without reason and without any impact on you. If you decide to withdraw, any data collected from the teacher will be destroyed.

Will you know about the research results?
At the end of the research I will send you the key findings.

If you would like to be involved, please complete the following consent form and return to Justin Kit-yan Chu via kit.chu.16@ucl.ac.uk by 15th November 2019.

If you have any further questions before you decide whether to take part, you can reach me at kit.chu.16@ucl.ac.uk or my supervisor Dr Jennie Golding at j.golding@ucl.ac.uk.

This project has been reviewed and approved by the UCL IOE Research Ethics Committee Z6364106/2019/11/28.

Data Protection Privacy Notice

Notice:

The data controller for this project will be University College London (UCL). The UCL Data Protection Office provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk. UCL's Data Protection Officer is Lee Shailer and he can also be contacted at data-protection@ucl.ac.uk.

Your personal data will be processed for the purposes outlined in this notice. The legal basis that would be used to process your personal data will be the provision of your consent. You can provide your consent for the use of your personal data in this project by completing the consent form that has been provided to you.

Your personal data will be held for 10 years. We will anonymise or pseudonymise the personal data you provide, and will endeavour to minimise the processing of personal data wherever possible.

If you are concerned about how your personal data is being processed, please contact UCL in the first instance at data-protection@ucl.ac.uk. If you remain unsatisfied, you may wish to contact the Information Commissioner's

Thank you for reading this leaflet. The research is of great importance in providing information about teachers' perspectives on their approaches used to support student engagement in biology and we hope you will take part.

Yours sincerely,

Mr Justin Chu
UCL Institute of Education
kit.chu.16@ucl.ac.uk

Dr Jennie Golding
UCL Institute of Education
j.golding@ucl.ac.uk

UCL Institute of Education
20 Bedford Way, London WC1H 0AL

Appendix 1.3 Information sheet – Students

Institute of Education

Student engagement in first-year university biology: course tutors' perspectives on their approaches to support engagement

Information Sheet for Students

This leaflet tells you about my research. I very much hope that you would like to take part. This information sheet will try and answer any questions you might have about the project, but please don't hesitate to contact me if there is anything else you would like to know.

Why is this research being done?
Improving student engagement in science, particularly during the critical transitional first-year university, is an important issue in education. To achieve this, it is necessary to understand what can be done to support student engagement. One of which is to understand first-year university tutors' perspectives on their approaches to promote student engagement, as this study aims to. This study will be conducted at UTS Insearch and focus on one subject area within the science discipline – biology. The results of the study will inform previous research on biology teaching; and generate implications for other first-year biology tutors to promote student engagement.

Who is conducting the research?
Justin Kit-yan Chu, a Doctor of Education (EdD) student in the Curriculum, Pedagogy and Assessment Department at the University College London, Institute of Education (UCL IOE) under the supervision of Dr Jennie Golding. In this study, I am hoping to find out your teachers' perspectives on the approaches they use to support your engagement in biology.

Why am I being invited to take part?
Your biology tutors are participating in this study. Part of this study involves the video-recording of the tutorials where you will be there. Therefore, your participation in the tutorials will be observed and video-recorded.

What will happen if I choose to take part?
Your tutors will give you consent forms and please sign it. Four or more tutorials will be observed and recorded.

Will anyone know I have been involved?
Any video-recorded data will be kept securely. Your identities will be anonymised. The data and overall results of the study will share with my supervisor only. The finding will be reported in my EdD thesis and a written summary will also be disseminated to your teachers, also with the teachers' identities anonymised. The results may also be presented at professional conferences and in research publications. Secure storage of digital data, including audio and video recording and transcripts will be kept in a password protected system for 10 years after the research; and to which only the researcher and the supervisor have the access.

Do I have to take part?
It is entirely up to you whether or not you choose to take part. I do not anticipate that any problems would arise if you choose not to take part but would be pleased to talk with you at any stage about any aspect of the project.

I hope that if you do choose to be involved then you will find it a valuable experience. Your participation is contributing to my understanding of how to support student engagement in biology at UTS Insearch. Promoting student engagement is a priority for you, me and the institute. You are free to withdraw from the study at any time before the end of the study period (i.e. December 2020) without reason and without any impact on you. If you decide to withdraw, any data collected from you will be destroyed.

If you would like to be involved, please complete the following consent form and return it to your teacher by 15th November 2019.

If you have any further questions before you decide whether to take part, you can reach me at kit.chu.16@ucl.ac.uk or my supervisor Dr Jennie Golding at j.golding@ucl.ac.uk.

This project has been reviewed and approved by the UCL IOE Research Ethics Committee Z6364106/2019/11/28

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Your personal data will be held for 10 years. We will anonymise or pseudonymise the personal data you provide, and will endeavour to minimise the processing of personal data wherever possible.

If you are concerned about how your personal data is being processed, please contact UCL in the first instance at data-protection@ucl.ac.uk. If you remain unsatisfied, you may wish to contact the Information Commissioner's

Thank you for reading this leaflet. The research is of great importance in providing information about teachers' perspectives on their approaches used to support student engagement in biology and we hope you will take part.

Yours sincerely,

Mr Justin Chu
UCL Institute of Education
kit.chu.16@ucl.ac.uk

Dr Jennie Golding
UCL Institute of Education
j.golding@ucl.ac.uk

Appendix 2.1 Consent form – Teacher Participants

Institute of Education

UCL

Student engagement in first-year university biology: course tutors' perspectives on their approaches to support engagement

Course Tutor Consent Form

If you are happy to participate, please complete this consent form and return to Justin Kit-yan Chu by 15th November 2019.

	Yes	No
I have read and understood the information leaflet about the research.	☐	☐
I agree to be interviewed and for my interview to be audio recorded.	☐	☐
I agree to have my tutorials to be observed and video recorded.	☐	☐
I agree for you to use information that I provide in relation to this research study for anonymous quotation and analysis in connection with academic and scientific papers, presentations and other publications purposes. I understand that any use of the information related to this research will not reveal my identity.	☐	☐
I understand that I can withdraw from the project at any time before the end of study period (i.e. 31st December 2020), and that if I choose to do this, any data I have contributed will not be used	☐	☐
I understand the Data Protection Privacy Notice below.	☐	☐

Data Protection Privacy Notice

Notice:

The data controller for this project will be University College London (UCL). The UCL Data Protection Office provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk. UCL's Data Protection Officer is Lee Shailer and he can also be contacted at data-protection@ucl.ac.uk.

Your personal data will be processed for the purposes outlined in this notice. The legal basis that would be used to process your personal data will be the provision of your consent. You can provide your consent for the use of your personal data in this project by completing the consent form that has been provided to you.

Your personal data will be held for 10 years. We will anonymise or pseudonymise the personal data you provide, and will endeavour to minimise the processing of personal data wherever possible.

If you are concerned about how your personal data is being processed, please contact UCL in the first instance

	Yes	No
I understand that I can contact Justin Kit-yan Chu at any time	☐	☐

Name ________________________

Signed_________________________ Date _____________________

Researcher's name Justin Kit-yan Chu

Signed_________________________ Date _____________________

Appendix 2.2 Consent form – Dean of Studies

Institute of Education

Student engagement in first-year university biology: course tutors' perspectives on their approaches to support engagement

Nov 2019 – Dec 2020

Dean of Studies Consent Form

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

UCL IoE Research Ethics Committee Ref Z636410 6/2019/11/28

Thank you for considering approval for this research.

If you have any questions arising from the Information Sheet or explanation already given to you, please ask one of the researchers before you decide whether to give approval. You will be given a copy of this Consent Form to keep and refer to at any time.

Statement by the Dean of Studies

Please tick the relevant box:

- I understand that if I decide at any time during the research that I no longer wish the institution to participate in this project, I can notify Mr. Justin Kit-yan Chu or his supervisor, Dr. Jennie Golding and withdraw from it immediately without giving any reason. Furthermore, I understand that I will be able to withdraw data up to 31st December 2020. Yes ☐ No ☐
- I consent to the processing of information provided by the institution tutors and students for the purposes explained to me, including the recording of interviews and tutorials where tutors are happy with that. I understand that such information will be treated in accordance with the terms of the Data Protection Act 1998, and will be securely stored in accordance with UCL guidelines for up to ten years, purely for research purposes. Yes ☐ No ☐
- I give permission for you to use information relating to this research for quotation and analysis in connection with academic and scientific papers, presentations and other publications purposes. I understand that the information related to this research will not reveal my identity or the identity of the tutors and students involved. I understand that any such use of data would be reviewed and approved by a research ethics committee. Yes ☐ No ☐

Participant's Statement: I___________________________(Dean of Studies's name), Dean of Studies of UTS Insearch, agree that the research project named above has been explained to me to my satisfaction and I agree to school teachers and pupils taking part in the study. I have read both the notes written above and the Information Sheet about the project, and understand what the research study involves.

Signature: ____

Date: ____

Institute of Education

UCL

Student engagement in first-year university biology: course tutors' perspectives on their approaches to support engagement

Student Consent Form

	Yes	No
The researcher, Mr. Justin Kit-yan Chu, has explained the purpose of video-recording of the lesson.	☐	☐
I agree to have my participation in the tutorials to be observed and video recorded. If I change my mind, I will let Justin Kit-yan Chu know.	☐	☐
I understand that I can contact Justin Kit-yan Chu at any time	☐	☐

Student Name: ________________________

Signed: ________________________ Date: ________________________

- -

Researcher's name Justin Kit-yan Chu

Signed: ________________________ Date: ________________________

UCL Institute of Education
20 Bedford Way, London WC1H 0AL

Appendix 3 Examples of lesson observation summary

Teacher A

Subject: Cell Biology and Genetics

Duration: 1 hour

Learning materials

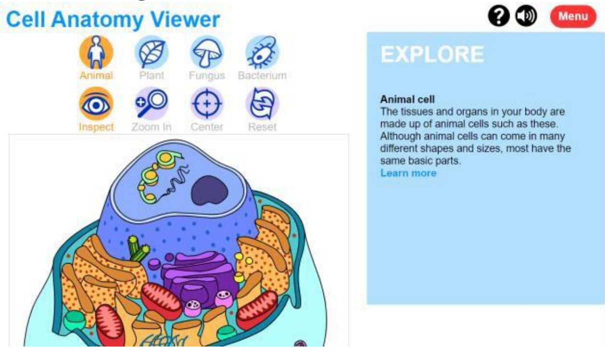
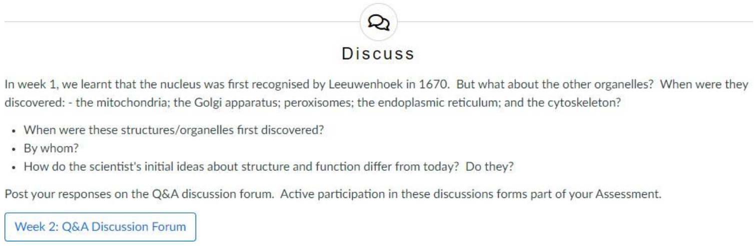
- Tutorial worksheet (attached)

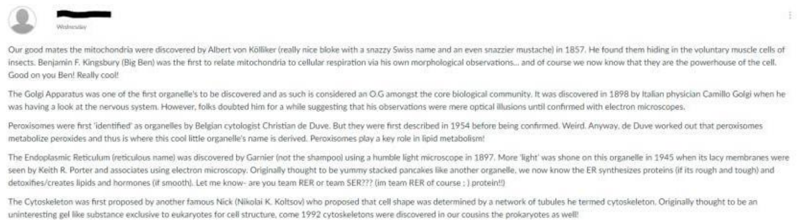
Learning activities

Event	Description
Extracellular Components	Students downloaded Tutorial worksheet from Canvas. Teachers discussed extracellular components – those outside the plasma membrane, providing structure and functionality to the cell - with the class. Some concepts were built on the concepts introduced in pre-tutorial work.
Endosymbiosis	Students watched the video clip (2mins) on endosymbiotic theory – the evolutionary theory, explaining how prokaryotic cells evolved into eukaryotic cells. Students were then divided into groups of 3-4 and discussed how the theory evolved and what scientific evidence is behind it. Teacher held the whole-class discussion on the theory.

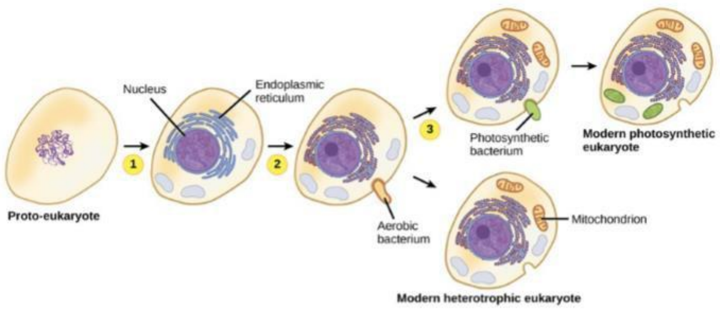
List of strategies mentioned by the teachers during the initial interviews:

Strategies	Implemented during the live tutorial?	Note
Breaking down complex concepts	✓	Pre-tutorial activities introduced individual organelles, the function of discrete organelles and how they function together to support the cell. Video 
Canvas as a platform for chunking	✓	
Videos, readings, mini-presentations, simulations, interactive quizzes	✓	
Pre-tutorial learning activities	✓	

		Interactive game  Discussion Forum  Discuss In week 1, we learnt that the nucleus was first recognised by Leeuwenhoek in 1670. But what about the other organelles? When were they discovered: - the mitochondria; the Golgi apparatus; peroxisomes; the endoplasmic reticulum; and the cytoskeleton? • When were these structures/organelles first discovered? • By whom? • How do the scientist's initial ideas about structure and function differ from today? Do they? Post your responses on the Q&A discussion forum. Active participation in these discussions forms part of your Assessment. Week 2: Q&A Discussion Forum
Complex concepts explained by students		
Hands-on activities		
Home experiments		
Demonstration		
Reflection task after collaborative activity		
Collaboration	✓	Students discussed how the endosymbiosis theory evolved and what scientific evidence is behind it.
Structured and balanced discussions		
Subject relevance to future learning and future career		
Self-Paced learning	✓	Pre-tutorial
Blended learning	✓	Both pre-tutorial and in-tutorial
Timely and formative	✓	Teacher held the whole-class discussion on the theory based on the discussion questions.

Feedback		
Individualised Feedback		
Broadening thinking through reading others' feedback	✓	In the discussion forum  [redacted] Wednesday Our good mates the mitochondria were discovered by Albert von Kölliker (really nice bloke with a snazzy Swiss name and an even snazzier mustache) in 1857. He found them hiding in the voluntary muscle cells of insects. Benjamin F. Kingsbury (Big Ben) was the first to relate mitochondria to cellular respiration via his own morphological observations... and of course we now know that they are the powerhouse of the cell. Good on you Ben! Really cool! The Golgi Apparatus was one of the first organelle's to be discovered and as such is considered an O.G amongst the core biological community. It was discovered in 1898 by Italian physician Camillo Golgi when he was having a look at the nervous system. However, folks doubted him for a while suggesting that his observations were mere optical illusions until confirmed with electron microscopes. Peroxisomes were first 'identified' as organelles by Belgian cytologist Christian de Duve. But they were first described in 1954 before being confirmed. Weird. Anyway, de Duve worked out that peroxisomes metabolize peroxides and thus is where this cool little organelle's name is derived. Peroxisomes play a key role in lipid metabolism! The Endoplasmic Reticulum (reticulous name) was discovered by Garnier (not the shampoo) using a humble light microscope in 1897. More 'light' was shone on this organelle in 1945 when its lacy membranes were seen by Keith R. Porter and associates using electron microscopy. Originally thought to be yummy stacked pancakes like another organelle, we now know the ER synthesizes proteins (if its rough and tough) and detoxifies/creates lipids and hormones (if smooth). Let me know- are you team RER or team SER??? (im team RER of course ;) protein!!) The Cytoskeleton was first proposed by another famous Nick (Nikolai K. Koltsov) who proposed that cell shape was determined by a network of tubules he termed cytoskeleton. Originally thought to be an uninteresting gel like substance exclusive to eukaryotes for cell structure, come 1992 cytoskeletons were discovered in our cousins the prokaryotes as well!

List of additional strategies demonstrated by the teachers during the lesson:

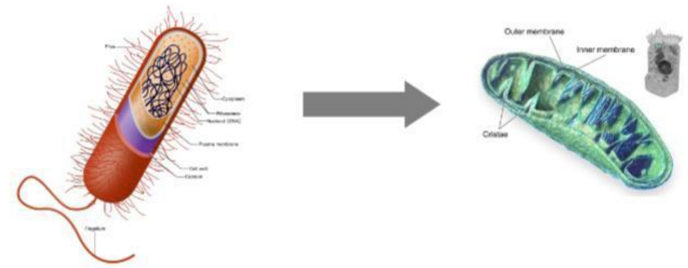
Strategies	Note
Simplifying and clarifying instructions	Teacher provided students clear instructions at the time of tutorial (not written on the worksheet) to prevent excessive information presented on the worksheet.
Integration of information Labeling information for reference	Students watched the video clips and then complete the flowchart diagram that explains the theory and process of endosymbiosis. The flowchart now becomes the all-in-one information required for the discussion task to occur. **Exercise 2: Endosymbiosis** A. Endosymbiotic theory is the evolutionary theory, explaining the origin of eukaryotic cells from prokaryotic cells. It states that several key organelles of eukaryotes originated as a symbiosis between separate single-celled organisms.  From the video and your study notes, complete labelling for the diagram above. Step 1: Infoldings of the plasma membrane Step 2: In the first endosymbiotic event, the ancestral eukaryote consumed aerobic bacteria which evolved into the mitochondria Step 3: In the second endosymbiotic event, the early eukaryote consumed photosynthetic bacteria which then evolved into a chloroplast
Motivating students to participate in collaborative activities with guided questions, hints, diagram and options / stimulating thinking	A set of guided questions (page 3-5) are provided for students to discuss the theory and process of endosymbiosis. Questions/options/aspects to stimulate student thinking about the similarities between prokaryotes and eukaryotes:

<table>
<tr>
<td></td>
<td>
similarities between them have further supported the hypothesis. Complete the table below. (5)

<table>
<tr><th></th><th>Similarities between the mitochondrion and the bacterium</th></tr>
<tr><td>Size</td><td>similar / different size range;
only be seen by light microscope / electron microscope</td></tr>
<tr><td>Shape</td><td>spherical / rod / spiral (bacillus)</td></tr>
<tr><td>Structure</td><td>both have circular / linear DNA</td></tr>
<tr><td>Reproduction</td><td>both by meiosis / binary fission</td></tr>
</table>

Diagram to stimulate students to propose the structural changes from prokaryotes to eukaryotes:

C. Though there are evident similarities, bacterial cells had to undergo some necessary structural changes to evolve into a mitochondrion. Using the diagram below as a hint, state the structures that had to be removed and developed.



<table>
<tr><th></th><th>Structures to be</th></tr>
<tr><td>Removed: (6)</td><td></td></tr>
<tr><td>Developed: (1)</td><td></td></tr>
</table>
</td>
</tr>
<tr>
<td>Space for students to record their outcomes from the discussion activitiy</td>
<td></td>
</tr>
<tr>
<td>Time: for preparation and discussion + extending collaborative and discussion time</td>
<td>Time was provided for students to discuss the questions. Additional time (5 mins) was given for students to wrap their discussion.</td>
</tr>
</table>

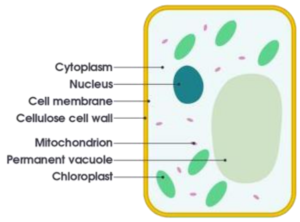
Cell Biology and Genetics, SCBG001

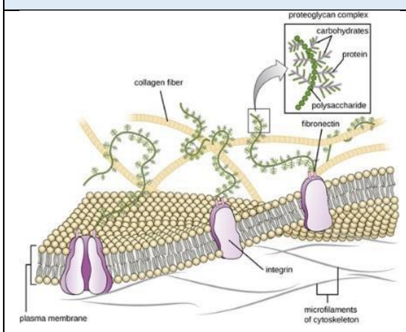
Tutorial - Eukaryotic Cells

Exercise 1: Extracellular Components

Extracellular components are those elements that live outside the plasma membrane, providing structure and functionality to the cell. In this subject, we look at three components:-

- The cell wall
- The extracellular matrix (ECM)
- Intercellular junctions

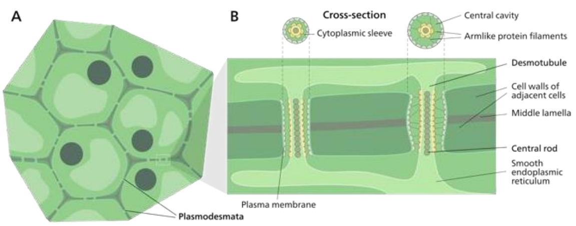
The cell Wall	Notes
 	Which species have a cell wall? · . Animals · . Plants · . Fungi · . Bacteria
	It functions in • Maintaining shape • Structural support • Protection Preventing excessive uptake of________________.

The extracellular matrix (ECM)	Notes
 	Because animals lacks a cell wall, they have an elaborate ECM. • This functions in support, adhesion, movement, and regulation. • It is made up on glycoproteins and proteoglycans. • Glycogen forms strong fibres outside the cell.

Intercellular Junctions

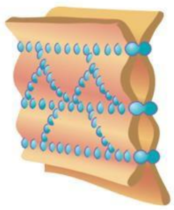
Intercellular junctions provide a means of neighbouring cells adhering and communicating with each other. Cell junctions connect neighbouring cells.

- Plant cells use plasmodesmatas.
- Animal cells use:-
    - Tight junctions
    - Desmosomes
    - Gap junctions



Plasmodesmata

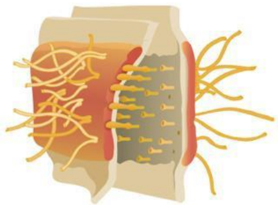
- Plants have holes (pores) punched in the cell wall.
- These allow for cytoplasmic exchange between neighbouring cells.



tight junctions

Tight Junctions

- Cells are pressed together, preventing leakage of extracellular fluid.
- ‘superglue’
- Eg. ____________________



desmosomes

Desmosomes

- Anchoring junctions
- Fasten cells together into strong sheets
- Eg. _______________

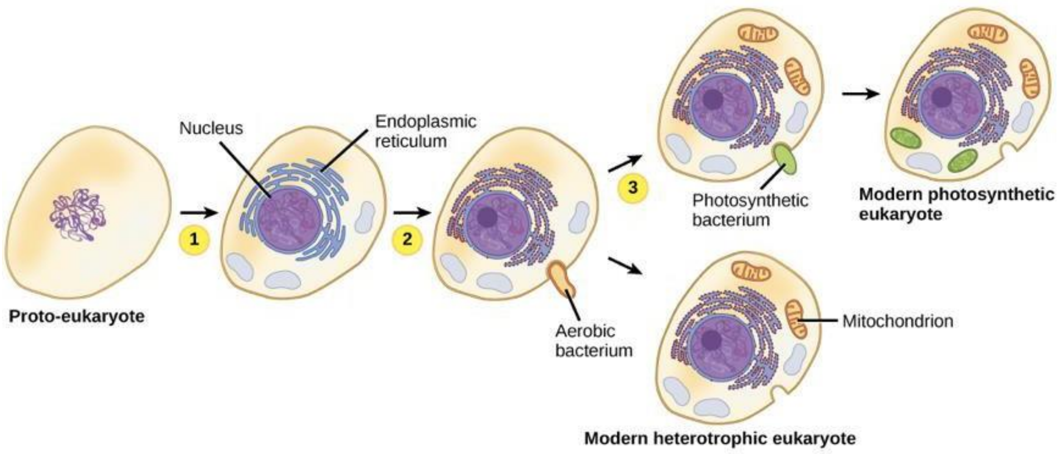
gap junctions

Gap Junctions (animals)

- Communication junctions
- Tunnels
- Provide cytoplasmic channels between adjacent cells
- Eg. ___________________________

Exercise 2: Endosymbiosis

A. Endosymbiotic theory is the evolutionary theory, explaining the origin of eukaryotic cells from prokaryotic cells. It states that several key organelles of eukaryotes originated as a symbiosis between separate single-celled organisms.



From the video and your study notes, complete labelling for the diagram above.

Step 1: Infoldings of the plasma membrane

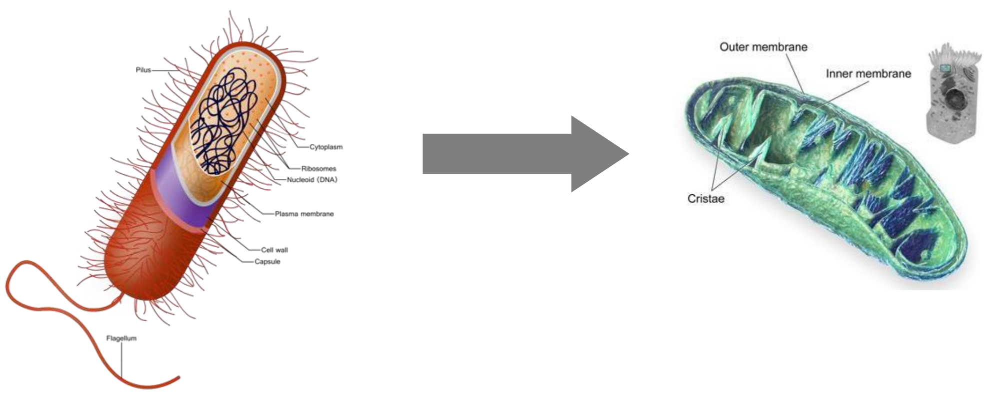
Step 2: In the first endosymbiotic event, the ancestral eukaryote consumed aerobic bacteria which evolved into the mitochondria

Step 3: In the second endosymbiotic event, the early eukaryote consumed photosynthetic bacteria which then evolved into a chloroplast

B. In order to support the endosymbiotic hypothesis, scientists compared the **size, shape, structure and reproductive method** between a bacterial cell and a mitochondrion. The similarities between them have further supported the hypothesis. Complete the table below. (5)

	Similarities between the mitochondrion and the bacterium
Size	*similar / different* size range; only be seen by *light microscope / electron microscope*
Shape	*spherical / rod / spiral (bacillus)*
Structure	both have *circular / linear* DNA
Reproduction	both by *meiosis / binary fission*

C. Though there are evident similarities, bacterial cells had to undergo some necessary structural changes to evolve into a mitochondrion. Using the diagram below as a hint, state the structures that had to be removed and developed.



	Structures to be
Removed: (6)	
Developed: (1)	

D. Mitochondria do not have flagella or cilia for movement. State ***one*** cellular structure that can relocate mitochondria in the cell.

____

References

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Wikimedia commons. (2014, March 14). *Plasmodesmata* [Image]. Plasmodesmata. https://commons.wikimedia.org/wiki/File:Plasmodesmata_en.svg

Wikimedia commons. (2015a, October 12). *Prokaryote Cell* [Image]. https://commons.wikimedia.org/wiki/File:Prokaryote_cell.svg

Wikimedia commons. (2016, January 27). *Simple diagram of plant cell* [Image]. https://commons.wikimedia.org/wiki/File:Simple_diagram_of_plant_cell_(en).svg

Teacher B

Subject: Nature and Evolution

Duration: 1 hour

Learning materials

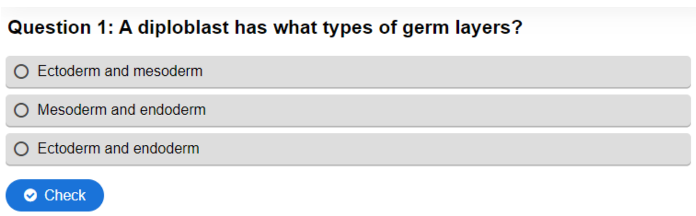
- Tutorial worksheet (attached)

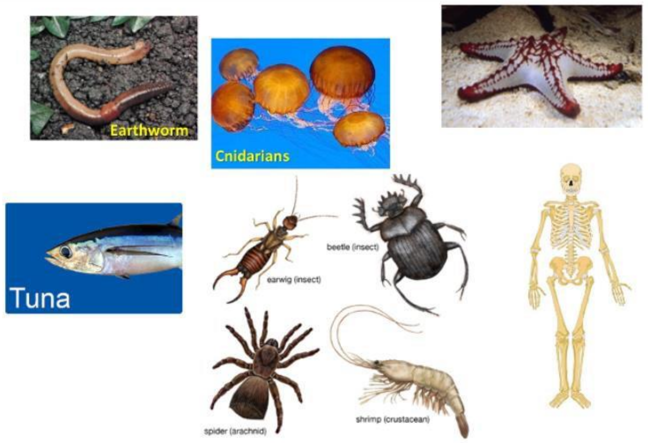
Learning activities

Event	Description
Concluding the subject by unpacking the message in the subject description	Teacher led the students for a guided whole-class discussion to unpack the message in the subject description: *"The existence of humans on earth has arguably been made possible through the evolution of a vast diversity of biota – to which we are inextricably linked, both directly and indirectly. Earth's biodiversity is not only extraordinary and fascinating but also fundamental to our ongoing survival. An understanding of the biological complexity of life is an important component underpinning a career in science, irrespective of the chosen scientific profession.* This subject investigates the question: what does it take for life to exist in the range of habitats across the globe?"
Structural adaptations to address the problem of desiccation	Students discussed how seed plants and mammals living in the terrestrial environment address the problem of desiccation. Students were given time to understand the task requirements, then discussed the issue based on the guided questions and hints. Finally, each group presented their response.

List of strategies mentioned by the teachers during the initial interviews:

<table>
<tr><th>Strategies</th><th>Implemented during the live tutorial?</th><th>Note</th></tr>
<tr><td>Breaking down complex concepts</td><td>✓</td><td rowspan="4">Learning or synthesis of concepts is based on prior knowledge introduced in the earlier modules on Canvas.

Interactive quizzes:

</td></tr>
<tr><td>Canvas as a platform for chunking</td><td>✓</td></tr>
<tr><td>Videos, readings, mini-presentations, simulations, interactive quizzes</td><td>✓</td></tr>
<tr><td>Pre-tutorial learning activities</td><td>✓</td></tr>
</table>

		Question 4: Skeletons provide support, protection and movement. There are three main types of skeleton (exoskeleton, endoskeleton and hydroskeleton).  **Using the provided animals above as examples, give one example of each type.** Exoskeleton: Endoskeleton: Hydroskeleton: Check **Question 6: Drag the provided words to complete the sentences below:** 1. The uptake of small nutrient molecules from the environment is known as ______. 2. One of many filaments making up the body of a fungus is called a ______. 3. The densely branched network of fungal filaments is a ______. 4. A ______ is a close association of fungi and plant roots that is beneficial to both. 5. An organism that derives its nutrition from a living host is called a ______. parasite absorption hypha mycorrhiza mycelium Check
Complex concepts explained by students		
Hands-on activities		
Home experiments		
Demonstration		
Reflection task after collaborative activity	✓	Question 3 on the Worksheet ***Question 3. Reflective Activity (Total: 10 minutes)*** Go through the answer keys in today's worksheet. Write down three to five pieces of information (knowledge) that you did not know before this tutorial on Week 11 Discussion forum. Remember what you have learnt today will be beneficial for your Major Quiz 2 (Final exam)!
Collaboration	✓	Question 2 – students to discuss how seed plants and mammals living in the terrestrial environment address the problem of desiccation.

Structured and balanced discussions	✓	Worksheets in question 2 provides various items to be discussed for seed plants and mammals to address desiccation.
Subject relevance to future learning and future career		
Self-Paced learning	✓	In the pre-tutorial learning activities
Blended learning	✓	
Timely and formative Feedback	✓	Teacher held the whole-class discussion based on the questions.
Individualised Feedback		
Broadening thinking through reading others' feedback		

List of additional strategies demonstrated by the teachers during the lesson:

<table>
<tr><th>Strategies</th><th>Note</th></tr>
<tr><td>Unpacking the focus of the question</td><td>
Worksheet Question 1
Unpacking the message in the subject description
<table>
<tr><th>Message</th><th>Questions to think</th></tr>
<tr><td>This subject investigates the question: what does it take for life to exist in the range of habitats across the globe?</td><td>What are the six habitats?

What are the two main habitats that you have come across in this subject?</td></tr>
<tr><td>There is considerable variation among living organisms, including humans, in their biology and how they interact with their environment.</td><td>What does ‘variation’ mean here?</td></tr>
</table>
Worksheet Question 2
Seed plants and mammals living in the terrestrial environment are subject to the problem of desiccation. Discuss the adaptations which enable them to overcome this problem.
<table>
<tr><th>Guided questions</th></tr>
<tr><td>What are the two members of the seed plants?</td></tr>
</table>
</td></tr>
<tr><td>Motivating students to participate in collaborative activities with guided questions, hints, diagram and options / stimulating thinking</td><td>A set of guided questions are provided for students.

Hints and questions:</td></tr>
</table>

Selecting relevant areas/aspects for discussion

Encouraging meaningful and substantive discussions

Seed plants

	Guided questions and hints
Absorption of water	Any adaptive features to facilitate the absorption of water? (Hint: which structure is to absorb water in plants? What special features do they have to absorb more water?)
Maintenance of water	Any adaptations for water conservation? (Hint: cellular structure)
Prevention of water loss	Any structural adaptations to prevent water loss? (Hints: leaf, stem, seed, fruit)
	Regarding the gas exchange surface, are there any adaptations to prevent water loss? (hint: where do plants conduct their gas exchange?)
	In reproduction, how gametes and embryos are prevented from desiccation? (hint: gametes – the pollens, and the embryo is inside the seed)

Diagram

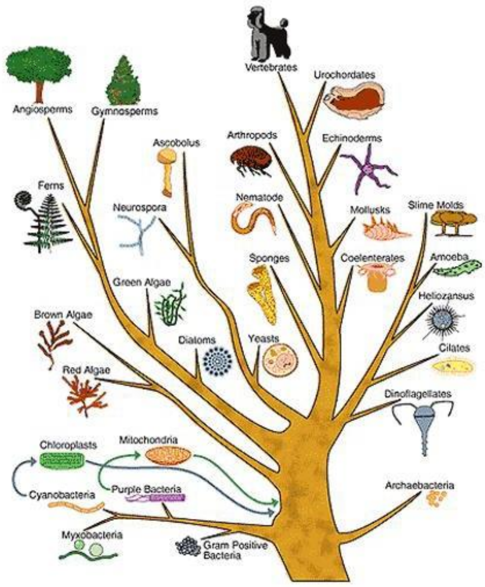


Figure 1. Evolution tree

Space for students to record their outcomes from the discussion activity

Presenting response from each group (20 mins)

Areas	**Seed plants**	**Mammals**
Absorption of water		
Maintenance of water		
Prevention of water loss		

Role allocation for collaboration	Students nominated themselves as the discussion leader, scripts and presenter. The teacher also facilitated the role assignation.
Time: for preparation and discussion + reporting/response	Adequate time (20mins) was provided for students to discuss the questions. Time (4-5 mins/group) for each group to present their response.
Monitoring	Teachers broadcasted messages to the breakout rooms.
Peer-evaluation	Teachers asked students from other groups to comment on each presentation.
Debriefing collaborative activities with encouragement	Teacher purposeful praised for individuals or groups. Teacher showed facial expressions indicating encouragement, recognition, and pride. Overall, teacher boosted student competence through noticing and praising.
Use of reflection to understand its benefits	Showed the importance of students realising the benefits themselves Support the rationale behind collaboration among peers. ***Question 3. Reflective Activity (Total: 10 minutes)*** Go through the answer keys in today's worksheet. Write down three to five pieces of information (knowledge) that you did not know before this tutorial on Week 11 Discussion forum. Remember what you have learnt today will be beneficial for your Major Quiz 2 (Final exam)! ____________________ ____________________ ____________________

SNAE001 Nature and Evolution

Week 11 Tutorial

Question 1. Classroom Discussion Activity (Total: 10 minutes)

Read the description of this subject.

The existence of humans on earth has arguably been made possible through the evolution of a vast diversity of biota – to which we are inextricably linked, both directly and indirectly. Earth's biodiversity is not only extraordinary and fascinating but also fundamental to our ongoing survival. An understanding of the biological complexity of life is an important component underpinning a career in science, irrespective of the chosen scientific profession. This subject investigates the question: what does it take for life to exist in the range of habitats across the globe?

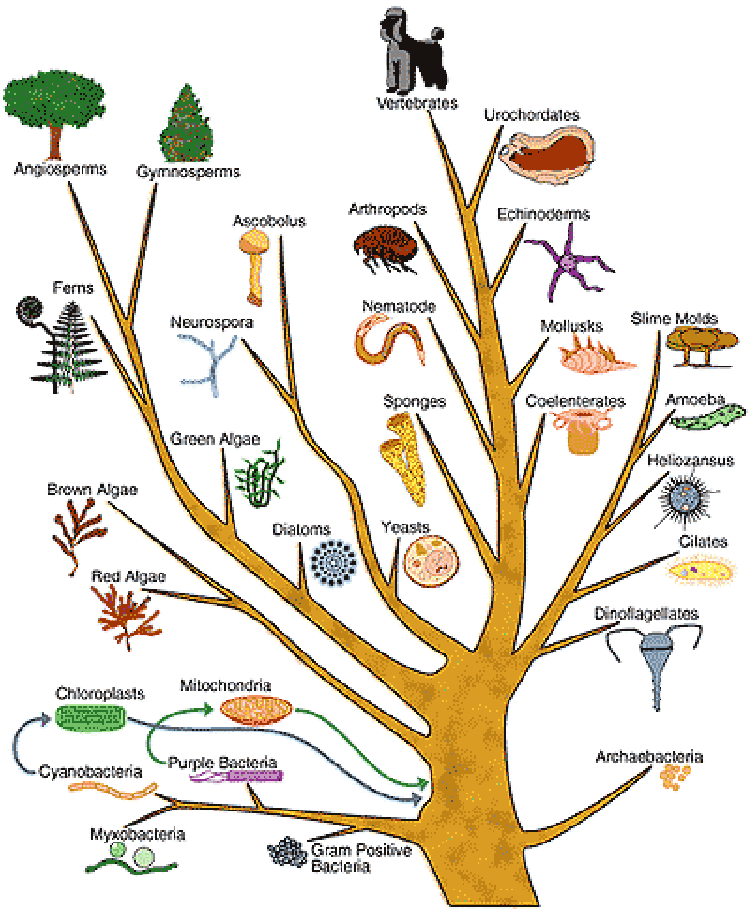


Figure 1. Evolution tree

Task: to unpack the message in the subject description

Message	Questions to think
• This subject investigates the question: what does it take for life to exist in the range of habitats across the globe?	What are the six habitats? What are the two main habitats that you have come across in this subject?
• There is considerable variation among living organisms, including humans, in their biology and how they interact with their environment.	What does 'variation' mean here?
• This subject explores the problems faced by organisms living in different habitats and demonstrates the strategies of plants, animals, fungi, protists, bacteria and archaea (examples) that have evolved to cope with the vast array of habitats on earth.	What challenges do organisms face in water? What challenges do organisms face in the terrestrial habitats? Strategies to cope with these challenges – they are in Collaborative activities in Tut A and B

• The order in which these biota are treated is reflected in the order of the evolution of life, i.e. movement from water to land (and in some cases back again). • All major taxa are discussed comparatively to better demonstrate the diversity of evolutionary strategies that have evolved in response to environmental conditions.	The Evolution tree diagram (refer to Figure 1 below) Which cases are back again? All major taxa are discussed comparatively – as demonstrated in Collaborative activities in Tut B.
• The subject also considers the sustainable use of animals, plants, fungi and bacteria as resources for humans.	Could you name some examples in the discussion forum this week?

<u>Question 2. Collaborative Activity (Total: 40 minutes)</u>

- Understanding the task requirements (5 mins)
- Reading the guided questions and hints, and drafting the response (15 mins)
- Presenting response from each group (20 mins)

Understanding the task requirements (5 mins)

Seed plants and **mammals** living in the terrestrial environment are subject to the problem of desiccation. Discuss the adaptations which enable them to overcome this problem.

Guided questions
What are the two members of the seed plants?

Reading the guided questions and hints, and drafting the response (15 mins)

<u>Seed plants</u>

Guided questions and hints	
Absorption of water	Any adaptive features to facilitate the absorption of water? (Hint: which structure is to absorb water in plants? What special features do they have to absorb more water?)
Maintenance of water	Any adaptations for water conservation? (Hint: cellular structure)
Prevention of water loss	Any structural adaptations to prevent water loss? (Hints: leaf, stem, seed, fruit)
	Regarding the gas exchange surface, are there any adaptations to prevent water loss? (hint: where do plants conduct their gas exchange?)
	In reproduction, how gametes and embryos are prevented from desiccation? (hint: gametes – the pollens, and the embryo is inside the seed)

<u>Mammals</u>

Guided questions and hints	
Absorption of water	Any adaptive features to facilitate the absorption of water? (e.g. any behaviours?, which part of the digestive system facilities the water absorption?)

Maintenance of water	Any adaptations for water conservation? (hint: which organ is to regulate the water content in our body?)	
Prevention of water loss	Any structural adaptations to prevent water loss? (hint: our skin?)	
	Regarding the gas exchange surface, are there any adaptations to prevent water loss? (hint: where is it? surface or deep down inside our body?)	
	In reproduction, how gametes and embryos are prevented from desiccation?	

Presenting response from each group (20 mins)

Areas	Seed plants	Mammals
Absorption of water		
Maintenance of water		

Prevention of water loss		

Question 3. Reflective Activity (Total: 10 minutes)

Go through the answer keys in today's worksheet. Write down three to five pieces of information (knowledge) that you did not know before this tutorial on Week 11 Discussion forum. Remember what you have learnt today will be beneficial for your Major Quiz 2 (Final exam)!

____

____

____

____

Appendix 4 - Interview guide and schedule

INITIAL INTERVIEWS

Hi, thank you for participating in this research. Just a reminder that this research aims to explore teachers' practices that support student engagement in biology.

The results of this study will be used for my doctoral thesis, for presentation at academic conferences and for professional development and publication.

I will record this interview, and I will make notes during the interview. All information provided will be treated, as far as possible, anonymously and confidentially, and pseudonyms will be used when reporting. Also, thank you for your consent form.

This interview focuses on your background and experience, what you do to support student engagement, and how you develop your self-efficacy in online teaching.

It will take about 60 minutes. Do you have any questions? (pause)

To Zoom: Interview with teacher ……on (date)

Part 1 – General questions

1. What is your educational background?
2. How long have you been teaching at UTS College and in a tertiary environment? What brought you into teaching?
3. Do you have any other teaching experience?
4. Have you received formal training for teaching science? If yes, what sort of foci were they? How effective do you think the training was for your actual teaching in the classroom?
5. What subjects are you currently teaching?
6. How was the student feedback survey on the subjects that you teach? Do you mind telling me the overall rating?

Part 2 – Strategies to support student engagement in online learning

1. What does your typical lesson look like?
2. From your experience, what are the essential elements of engaging students in learning biology?
3. What do you do (approaches/strategies) to support student engagement in biology?

   Depending on participants' responses, the following prompts may be asked:

   - Going through weekly modules may allow you to think about what strategies you have been using.
   - Could you give me or show me some examples, like the worksheet or canvas pages, when using these approaches?
   - On what occasions do you use these approaches?
   - Have you used this approach in face-to-face classrooms before the pandemic?
   - Why do you think this approach can support student engagement online?
   - Do you have any evidence to decide whether that's effective?
   - Do you see any difficulties or limitations in using this / these approach(es)?

Part 3 – Development of teacher self-efficacy in online learning

1. Self-efficacy refers to perceived capability and confidence to achieve specific results – in this case, it would be to engage students in online learning. Recalling your experience in the last semester of online teaching, what did you consider your level of self-efficacy in engaging students online at that time?

2. Mastery experience:

   In the literature, teachers build their self-efficacy for online teaching through personal direct experience, which is known as mastery experiences. Reflecting on this type of experience,

   - Can you describe a specific instance during your online teaching experience when you encountered a challenge but managed to overcome it successfully? How did this experience contribute to building your self-efficacy for online teaching?
   - Reflecting on your journey as an online teacher, could you share an example of a time when you tried a new teaching approach or technology that led to positive student engagement and learning outcomes? How did this experience influence your confidence in your online teaching abilities?
   - In your online teaching practice, have you observed any improvements in student performance or motivation as a result of your strategies? How did these positive outcomes impact your belief in your capacity to be an effective online teacher?

3. Vicarious experience:

   - Have you ever participated in professional development or training related to online teaching? How did these experiences enhance your knowledge and skills, and how did they contribute to your sense of self-efficacy as an online educator?

4. Verbal persuasion:

   - Can you recall a time when you received positive feedback from students, colleagues, or others about your online teaching methods or the impact you had on student learning? How did this feedback contribute to your self-efficacy as an online teacher?

5. Emotional states:

   - How do you think your emotional state (e.g., feeling confident, stressed, motivated) can influence your belief in your ability to effectively teach online?
   - Reflecting on your experiences as an online educator, can you recall a specific instance when your emotional state positively impacted your self-efficacy for online teaching? What emotions were you experiencing at that time, and how did they contribute to your belief in your teaching abilities?
   - On the other hand, have you ever encountered a situation where your emotional state had a negative impact on your self-efficacy as an online teacher? How did these emotions influence your confidence in your online teaching capabilities?
   - How do you manage or cope with challenging emotions (e.g., frustration, anxiety) that may arise during your online teaching experiences? How do these coping strategies affect your self-efficacy beliefs for online teaching?
   - Can you identify any specific factors that tend to boost your emotional well-being and sense of satisfaction in your role as an online teacher? How do these positive emotions contribute to your perception of your effectiveness as an online teacher?

That’s all my questions for now. Is there anything you want to talk about or any questions to ask?

Thank you for your time and insightful answers. I look forward to observing how your students engage in the tutorials.

POST-LESSON INTERVIEWS

Hi, thank you for participating in this research. Just a reminder that this research aims to explore teachers' practices that support student engagement in biology.

I will record this interview, and I will make notes during the interview. All information provided will be treated, as far as possible, anonymously and confidentially, and pseudonyms will be used when reporting.

This interview focuses on what you do to support student engagement in your online tutorials.

It will take about 30 minutes. Do you have any questions? (pause)

To Zoom: Interview with teacher... on (date)

1. In that lesson, could you summarise the strategies or approaches that you have used to support student engagement in biology?
2. Depending on participants' responses, the following prompts may be asked:
    - In your lesson, I saw you conducting or students doing …/ have a look at this video clip, could you elaborate on this strategy?
    - Could you give me or show me more examples, like the worksheet or canvas pages, when using these approaches?
    - On what other occasions, do you use these approaches?
    - Have you used this approach in face-to-face classrooms before the pandemic?
    - Why do you think this approach can support student engagement online?
    - Do you have any evidence to decide whether that's effective?
    - Do you see any difficulties or limitations in using this / these approach(es)?

That's all my questions for now. Is there anything you want to talk about or any questions to ask?

Thank you for your time and insightful answers. I look forward to observing your other tutorials.

FINAL INTERVIEWS

Hi, thank you for participating in this research. Just a reminder that this research aims to explore teachers' practices that support student engagement in biology.

The results of this study will be used for my doctoral thesis, for presentation at academic conferences and professional development, and for publication.

I will record this interview, and I will make notes during the interview. All information provided will be treated, as far as possible, anonymously and confidentially, and pseudonyms will be used when reporting.

This interview focuses on two things: what you do to support student engagement and your development of self-efficacy for online teaching throughout the semester.

It will take about 60 minutes. Do you have any questions? (pause)

To Zoom: Interview with teacher... on (date)

Part 1 – Strategies to support student engagement in online learning

Thank you for sharing with me your strategies to engage students throughout the semester. Regarding the strategies, I would like to gather your views on the following three issues: sustaining concentration, effective collaboration, and independent learning. You could use the examples of strategies that you shared with me in the earlier interviews.

Depending on participants' responses, the following prompts may be asked:

Sustaining concentration

1. When it comes to sustaining concentration among students in the online learning environment, what strategies do you find most effective in keeping students engaged and focused during synchronous tutorials and asynchronous activities?
2. How do you handle potential distractions that students may encounter during online tutorials or asynchronous activities, and what do you do to minimise these distractions to enhance their concentration?
3. Previously, you mentioned that you used these strategies (e.g. …). Do you consider this strategy to address the issue of sustaining concentration?
4. Have you used this approach in face-to-face classrooms before the pandemic?
5. Do you see any difficulties or limitations in using this / these approach(es)?

Effective collaboration

6. In the context of online collaboration, could you share examples of successful activities or strategies you used to promote effective online group work and interaction among students?
7. How do you address challenges that may arise when facilitating group projects or collaborative tasks online, and what adjustments have you made to ensure seamless teamwork?
8. Previously, you mentioned that you used these strategies (e.g. …). Do you consider this strategy to address the issue of effective collaboration?
9. Have you used this approach in face-to-face classrooms before the pandemic?
10. Do you see any difficulties or limitations in using this / these approach(es)?

Independent learning

11. As students are learning independently in the online environment, what types of resources or support do you provide to help them stay motivated to learn independently online?

12. In what ways do you encourage students to take responsibility for their learning progress, and how do you foster a sense of autonomy in the online learning environment?
13. Previously, you mentioned that you used these strategies (e.g. …). Do you consider this strategy to address the issue of independent learning?
14. Have you used this approach in face-to-face classrooms before the pandemic?
15. Do you see any difficulties or limitations in using this / these approach(es)?

Part 2 – Development of teacher self-efficacy in online learning

6. Now, it is close to the end of the second semester of online teaching. What do you consider your level of self-efficacy in engaging students online now?
7. Previously, you shared with me how you built your self-efficacy for online teaching through personal direct experience. In the literature, these experiences are called mastery experiences. Reflecting on this type of experience, do you have additional comments / views, or thoughts on it?
8. During the second semester, have you had additional experiences observing others' successful practices that have contributed to your development in self-efficacy?
9. This semester, have you had further experience receiving verbal encouragement from others (colleagues, students, or significant others) that have successfully improved your self-efficacy?
10. After two semesters of online teaching, how do you see the importance of emotional states in influencing your self-efficacy?

That’s all my questions. Is there anything you want to talk about or any questions to ask?

Thank you for sharing your insights with me in this research.

Appendix 5.1 EdD ethics application form

Institute of Education UCL

Doctoral Student Ethics Application Form

Anyone conducting research under the auspices of the Institute of Education (staff, students or visitors) where the research involves human participants or the use of data collected from human participants, is required to gain ethical approval before starting. This includes preliminary and pilot studies. Please answer all relevant questions in simple terms that can be understood by a lay person and note that your form may be returned if incomplete.

Registering your study with the UCL Data Protection Officer as part of the UCL Research Ethics Review Process

If you are proposing to collect personal data i.e. data from which a living individual can be identified **you must be registered with the UCL Data Protection Office before you submit your ethics application for review**. To do this, email the complete ethics form to data-protection@ucl.ac.uk. Once your registration number is received, add it to the form* and submit it to your supervisor for approval.

If the Data Protection Office advises you to make changes to the way in which you propose to collect and store the data this should be reflected in your ethics application form.

Section 1 Project details

a.	Project title		Student engagement in first-year university biology: Teachers' perspectives on their approaches to support engagement		
b.	Student name and ID number (e.g. ABC12345678)		Justin Kit-yan Chu (16135937)		
c.	***UCL Data Protection Registration Number**		Z6364106/2019/11/28		
c.	Supervisor/Personal Tutor		Dr Jennie Golding		
d.	Department		Curriculum, Pedagogy and Assessment		
e.	Course category (Tick one)	PhD	☐	EdD	☒
		DEdPsy	☐		
f.	**If applicable,** state who the funder is and if funding has been confirmed.		N/A		
g.	Intended research start date		1 Nov 2019		
h.	Intended research end date		31 Dec 2020		
i.	Country fieldwork will be conducted in *If research to be conducted abroad please check www.fco.gov.uk and submit a completed travel risk assessment form (see guidelines). If the FCO advice is against travel this will be **required** before ethical approval can be granted: http://ioe-net.inst.ioe.ac.uk/about/profservices/international/Pages/default.aspx*		Sydney, Australia		

j.	Has this project been considered by another (external) Research Ethics Committee?	
	Yes ☐	External Committee Name:
	No ☒ ⇨ *go to Section 2*	Date of Approval:

If yes:

- Submit a copy of the approval letter with this application.
- Proceed to Section 10 Attachments**.**

Note: Ensure that you check the guidelines carefully as research with some participants will require ethical approval from a different ethics committee such as the National Research Ethics Service (NRES) or Social Care Research Ethics Committee (SCREC). In addition, if your research is based in another institution then you may be required to apply to their research ethics committee.

Section 2 Research methods summary (tick all that apply)

☒ Interviews	☐ Controlled trial/other intervention study
☐ Focus groups	☐ Use of personal records
☐ Questionnaires	☐ Systematic review ⇨ ***if only method used go to Section 5.***
☐ Action research	☐ Secondary data analysis ⇨ ***if secondary analysis used go to Section 6.***
☒ Observation	☐ Advisory/consultation/collaborative groups
☐ Literature review	☐ Other, give details:

Please provide an overview of the project, focusing on your methodology. This should include some or all of the following: purpose of the research, aims, main research questions, research design, participants, sampling, data collection (including justifications for methods chosen and description of topics/questions to be asked), reporting and dissemination. Please focus on your methodology; the theory, policy, or literary background of your work can be provided in an attached document (i.e. a full research proposal or case for support document). *Minimum 150 words required.*

Purpose and aims of the research

Improving student engagement in science, particularly during the critical transitional first-year university, is an important issue in education. To achieve this, it is necessary to understand what can be done to support student engagement. One of which is to understand first-year university teachers' perspectives on their approaches to promote student engagement, as this study aims to. This study will be conducted at UTS Insearch and focus on one subject area within the science discipline – biology.

Research questions

The study will be guided by two broad research questions (RQs) in the UTS Insearch context:
RQ1) What are teacher perspectives on the approaches they use to support student engagement in biology tutorials?
RQ2) What are the implications for other university biology teachers?

Research design - Qualitative case study approach

To thoroughly understand teachers' self-accounts of their practices and the underlying rationale, necessitates a qualitative approach to gather rich and varied descriptions from teachers. This approach is particularly suitable for studies that aim to 'exploring and understanding the meaning of individuals or groups ascribe to a social or human problem' (Creswell, 2009, p.29). Within the qualitative approach, a case study design is considered fit for purpose for four reasons. First, it can capture the complexity and subjectivity of the first-hand understanding of people and events and provide a rich, vivid and in-depth description of the situation (Cohen, Manion & Morrison, 2018). Second, it allows readers to understand how abstract ideas and principles can fit and occur in real contexts (Yin, 2009). This matches the aim of the current study to understand how teacher make decisions (abstract ideas) to choose and use practices that are supportive of student engagement (real contexts). The realisation of abstract ideas in real contexts are difficult to separate and must be understood in its wholeness

(Cohen et al. 2018). Thirdly, Cohen et al. (2018) suggest that the case study approach can establish the cause (e.g. rationale) and effect (e.g. selected approaches) of events in real contexts (i.e. teaching biology). Finally, the case study approach allows multiple tools for data collection and sources of evidence to blend in to build a comprehensive picture of what is occurring (Baxter & Jack, 2008). Data from interviews, lesson observation and artefacts in this study can be triangulated to minimise single-source bias (Cohen et al. 2018) – or, where there appear to be contradictions, to identify and explore those further.

Participants

Five teachers who teach Biology at UTS Insearch will be invited to participate in the study. I expected to select two teacher volunteers whose background variables are diverse, so providing a purposive sample. These variables include: tertiary teaching experience (at and outside UTS Insearch), years of work experience (e.g. secondary school teaching experience and/or industrial experience related to science), training background (e.g. with or without graduate certificate of teaching and learning for high education), and study experiences (e.g. whether they were once an international student in university).

Data collection procedures

Data will be collected from multiple sources to understanding teachers' practices and their rationale behind in three stages (see Figure 1). The data gathering methods include interviews with teachers, video-recorded tutorial observations, analysis of artefacts (e.g. lesson plans, worksheets, presentation slides) and field notes.

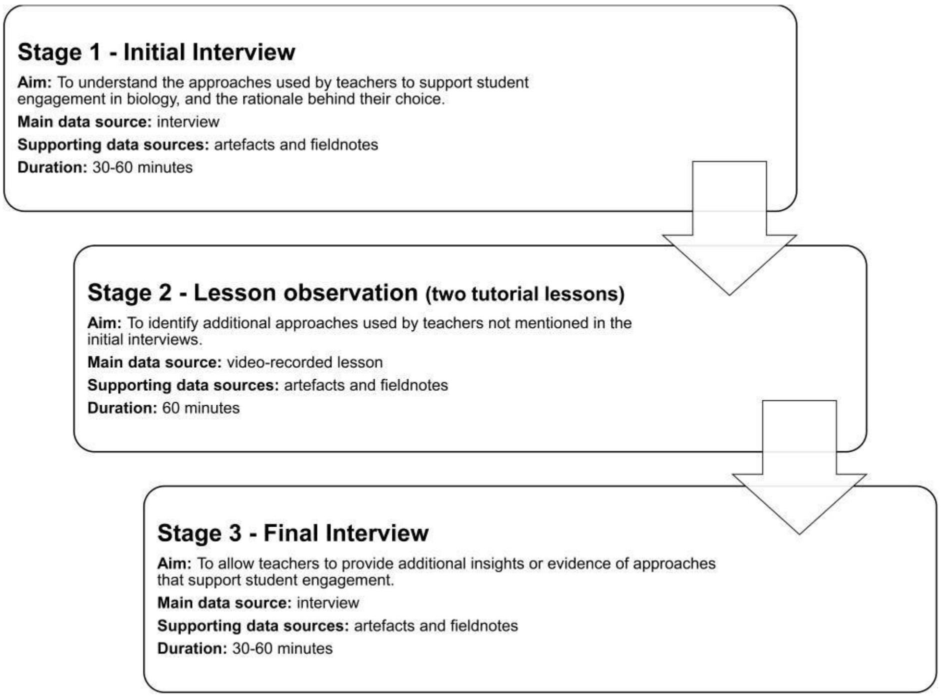


Figure 1. Three stages in data collection

Stage 1 – Initial Interview

Interviews with teachers will take place at UTS Insearch and be around 30 to 60 minutes in duration. Interviews will be audio-recorded and transcribed to assist analysis. Field notes will capture information that cannot be audio-recorded, for example the emotion expressed by the participants when sharing his/her approaches.

A semi-structured approach to interviewing will be adopted. This is to allow the interactional exchange of dialogue for teachers to express their views, feelings and thoughts; and interviewers to ask follow-up questions when clarification is needed (Mason, 2006; Zazkis & Hazzan, 1999). For RQ1, teachers are asked: 'What approaches do you use to support student engagement in biology?'. Other questions aimed at eliciting further information about the teaching approaches include: 'Can you provide an example of this approach?', 'On what occasions, do you use this approach?', 'Can you share your rationale behind your choice and use of this approach?', 'What challenges do you encounter when you use the approach to promote student engagement in biology?'. See Appendix A for the full draft interview schedule. Teachers will be invited to bring artefacts to support their claims.

Stage 2 – Lesson Observation

Two biology tutorials (60 minutes each) per each participant will be observed and video-recorded. The observation and recording are to capture actions and nuances that might be missed or hard to detail accurately during the initial interviews (Cohen et al., 2002). Field notes (see Appendix B) will be made during the lesson to record information that may not be captured by the video-recording, for example, the immediate impressions of significant teaching and learning moments, and aspects that could be used as a stimulus for discussion in the final interview. Artefacts, for example, lesson plans and lesson worksheet, will also be collected. The video segments, artefacts and fieldnotes that are related to approaches to promote student engagement will be identified and selected for stimulated recall in Stage 3. Additionally, observing teachers' practices in the lesson can also triangulate their views expressed during the interviews.

Stage 3 – Final Interview

Participants will be provided with the stimulated recall data in this interview to understand further their perspectives of the approaches adopted to support student engagement. Viewed as an introspective approach, this method retrieves participants' memory and allows them to reflect mental processes during the event (Bloom, 1953). This approach is particularly useful to gain the perspectives of participants, their interpretation of events and their thinking at a particular point in time (Mackey & Gass, 2005). In the current study, relevant segments of the video-recorded lessons, artefacts and field notes will be shown to participants and asked them about their perspectives of adopting those approaches to support engagement. The interview will be semi-structured, 30-60 minutes in duration and audio-recorded.

Data analysis

Interpretative paradigm

All interview data collected will be analysed under the interpretive paradigm. Paradigms, also known as worldviews, are general philosophical orientations bearing assumptions about the world (Creswell, 2009). Philosophically, the interpretive paradigm assumes that 'people make meanings in and through their activities … there are multiple interpretations of … single events and situations' (Cohen et al., 2007, pp. 20–21), and recognises 'understanding of individuals' interpretations of the world around them … through the eyes of different participants' (Cohen et al., 2007, p. 19). Therefore, data analyses under the interpretive paradigm seek to 'understand the subjective world of human experience; (Cohen et al., 2007, p. 21) by 'grasping how people interpret and make sense of their world and act on their interpretations' (Hammersley & Traianou, 2012, p. 27).

Data analysis procedure
Data will be analysed via a hybrid approach, combining both deductive and inductive processes, which allow IFS findings to be integral to the current study (Braun & Clarke, 2006; Fereday & Muir-Cochrane, 2006).

Reporting and dissemination

The finding will be reported in my doctoral thesis. Participants will be sent a summary of it. Findings will also be disseminated via academic and professional conferences and journals. I will ensure all participants are aware that all data collected may be used for these purposes.

References

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The Qualitative Report*, *13*(4), 544-559.

Bloom, B. S. (1953). Thought-processes in lectures and discussions. *The Journal of General Education*, *7*(3), 160-169.

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Hazzan, O., & Zazkis, R. (1999). A perspective on" give an example" tasks as opportunities to construct links among mathematical concepts. *Focus on Learning Problems in Mathematics*, *21*(4), 1-14.

Section 3 Research Participants (tick all that apply)

☐ Early years/pre-school
☐ Ages 5-11
☐ Ages 12-16
☐ Young people aged 17-18

☒ Adults *please specify below*
☐ Unknown – specify below
☐ No participants

Teacher participants in this study are all over 18.

NB: Ensure that you check the guidelines carefully as research with some participants will require ethical approval from a different ethics committee such as the National Research Ethics Service (NRES) or Social Care Research Ethics Committee (SCREC).

Section 4 Security-sensitive material (only complete if applicable)

Security sensitive research includes: commissioned by the military; commissioned under an EU security call; involves the acquisition of security clearances; concerns terrorist or extreme groups.

a.	Will your project consider or encounter security-sensitive material?	Yes ☐ *	No ☐
b.	Will you be visiting websites associated with extreme or terrorist organisations?	Yes ☐ *	No ☐
c.	Will you be storing or transmitting any materials that could be interpreted as promoting or endorsing terrorist acts?	Yes ☐ *	No ☐

* *Give further details in **Section 8 Ethical Issues***

Section 5 Systematic reviews of research (only complete if applicable)

a.	Will you be collecting any new data from participants?	Yes ☐ *	No ☐
b.	Will you be analysing any secondary data?	Yes ☐ *	No ☐

* *Give further details in **Section 8 Ethical Issues***

*If your methods do not involve engagement with participants (e.g. systematic review, literature review) **and** if* *you have answered **No** to both questions, please go to **Section 8 Attachments.***

Section 6 Secondary data analysis (only complete if applicable)

a.	Name of dataset/s		
b.	Owner of dataset/s		
c.	Are the data in the public domain?	Yes ☐	No ☐ ***If no,** do you have the owner's permission/license?* Yes ☐ No* ☐
d.	Are the data anonymised?	Yes ☐	No ☐
		Do you plan to anonymise the data? Yes ☐	No* ☐
		Do you plan to use individual level data? Yes* ☐	No ☐
		Will you be linking data to individuals? Yes* ☐	No ☐
e.	Are the data sensitive (DPA 1998 definition)?	Yes* ☐	No ☐
f.	Will you be conducting analysis within the remit it was originally collected for?	Yes ☐	No* ☐
g.	**If no,** was consent gained from participants for subsequent/future analysis?	Yes ☐	No* ☐
h.	**If no,** was data collected prior to ethics approval process?	Yes ☐	No* ☐

* *Give further details in **Section 8 Ethical Issues***

*If secondary analysis is only method used **and** no answers with asterisks are ticked, go to **Section 9 Attachments.***

Section 7 Data Storage and Security

Please ensure that you include all hard and electronic data when completing this section.

a. **Data subjects -** Who will the data be collected from? First-year biology teachers at UTS Insearch

b. **What data will be collected?** Please provide details of the type of personal data to be collected

- Subject(s) taught
- Length of teaching at UTS Insearch and in a tertiary environment; what brought them into teaching
- Other teaching experience
- Highest qualifications
- Formal training for teaching science

It is not an assessment of either the teaching of the teachers or the learning of their students. These data will be in the forms of audio recordings and anonymised transcripts about the teachers' use of approach to support student engagement.

c. **Disclosure** – Who will the results of your project be disclosed to? The data of the project will only be accessed by the supervisor and the researcher; and will not be disclosed to others. The data will be reported in my doctoral thesis with teachers not identifiable. Participants will be sent a summary of it. Findings will also be disseminated via

	academic and professional conferences and journals. I will ensure all participants are aware that all data collected may be used for these purposes. There will not be any sensitive information.
d.	**Data storage** – Please provide details on how and where the data will be stored i.e. UCL network, encrypted USB stick*, encrypted laptop* etc. Anonymised data will be stored on encrypted password-protected UCL N-Drive and transferred from password protected recorders. Recordings will be deleted once transferred to laptops. Only the researcher myself will have access to the names associated with data in consent forms, and any related data will be anonymised. *Advanced Encryption Standard 256 bit encryption which has been made a security standard within the NHS
e.	**Data Safe Haven (Identifiable Data Handling Solution)** – Will the personal identifiable data collected and processed as part of this research be stored in the UCL Data Safe Haven (mainly used by SLMS divisions, institutes and departments)? Yes ☐ No ☒
f.	How long will the data and records be kept for and in what format? 10 years in digital format Will personal data be processed or be sent outside the European Economic Area? (If yes, please confirm that there are adequate levels of protections in compliance with the DPA 1998 and state what these arrangements are: No Will data be archived for use by other researchers? (If yes, please provide details.) No

Section 8 Ethical issues

Please state clearly the ethical issues which may arise in the course of this research and how will they be addressed.

All issues that may apply should be addressed. Some examples are given below, further information can be found in the guidelines. *Minimum 150 words required.*

- Methods
- Sampling
- Recruitment
- Gatekeepers
- Informed consent
- Potentially vulnerable participants
- Safeguarding/child protection
- Sensitive topics
- International research
- Risks to participants and/or researchers
- Confidentiality/Anonymity
- Disclosures/limits to confidentiality
- Data storage and security both during and after the research (including transfer, sharing, encryption, protection)
- Reporting
- Dissemination and use of findings

Ethical issues:

1. Risks to participants:

- Vulnerability. Though course tutors who are adults are not regarded as vulnerable groups, tutors may feel vulnerable if they agree to be interviewed that their perspectives are being judged and under scrutiny. Additionally, the lesson observation will involve first-year students who are over 18. The video-recording may capture of faces of students and what they say and do in the tutorials. However, students will not be interviewed.
- Confidentiality and Anonymity.
- Conforming testimony to what is expected: They may feel constrained to give what they think the interviewer wants to hear rather than their honest opinion.

2. Data storage and security may be an issue when I make transcripts of the interviews.

3. Participant Selection:

- Equalities issues.
- Withdrawal.

4. Having dual role of subject coordinator and researcher.

5. Potential gatekeeper approval: Subject coordinators may refuse allowing their tutors to participate in the interview during office hours or at all.

<u>These are the steps I plan to take in order to address the issues above:</u>

1. **Risks to participants:**
   - **Vulnerability:** I will conduct the interviews at private meeting room in the institute to maintain their privacy. The first 5 minutes will be used to build rapport to make sure the participants are comfortable. During the interviews, I will be aware of any signs that the participants may feel a sense of intrusion or coercion. I will remind the participants that they can reject answering any questions if they feel uncomfortable and no reasons will be asked for. More importantly, I will endeavour to include participants' perspectives from the interviews in an objective way, to avoid treating their idea as a lack of knowledge or insight. I will take care to avoid any bias in my reporting.

     Students in those tutorials will be approached by emails, providing them the attached information, and ask to give their consent for the video-recording. Students who do not consent will not be filmed. Also, students will not be interviewed. This is a low risk study with some clear potential benefits to student's learning, and it is felt that this is a reasonable approach.
   - **Confidentiality and Anonymity**: Following BERA guidelines, individual identities and identification factors will not be disclosed during data collection, analysis, reporting and dissemination. To identify which participants have provided all levels of consent, I will keep a name list with first names linked to the unique identifiers. This sheet will remain with the researcher and the supervisor, and will be password-protected. I will prepare all transcripts and other study related materials, so no other individuals will have direct access to these data, including personal information. In the analysis and findings chapters of the final study, should participants be quoted, all the names will be anonymised. Also, I will make it clear that if significant extracts from interviews are quoted in the final report, I will first check the quotation and commentary with the course tutors concerned.
   - **Conforming Testimony**: I will ask participants to give honest answers and be aware of the risks of reinforcing certain responses over others by my own response to what participants say.
2. I will follow the Code of Ethics and Conduct from the British Psychological Society. Secure storage of digital data, including audio recording and transcripts will be stored in UCL N-Drive which is a password protected system to which only the researcher and the supervisor have the access. All data from the interviews will be anonymised and confidentiality guaranteed to participants.
3. Participant Selection:
   - **Equalities issues:** I will include participants irrespective of their gender, race, professional experience or status in the institute.
   - **Withdrawal:** I will make it clear that participants are free to withdraw at any time before the end of the study period (i.e. 31st August 2020); and will comply with any requests following withdrawal for data to be deleted if participants request this.
4. I will make it clear that I am interviewing in the role of a researcher. I will restrain from entering into discussions about individual students or to offer personal opinion and will redirect any such requests for discussion at a later date.

Subject coordinators will also receive the information sheet of the study through email so that they understand what data to be collected from their tutors. In addition, I will clearly state the necessity to the participants about the authorisation of their involvement with their subject coordinators. Also, if needed, I will be available to meet the coordinators who have queries and concerns about the study.

Section 9 Attachments Please attach the following items to this form, or explain if not attached			
a.	Information sheets, consent forms and other materials to be used to inform potential participants about the research *(List attachments below)*	Yes ☒	No ☐
	• Recruitment letter • Information sheet • Consent form • Interview schedule		
	If applicable/appropriate:		
b.	Approval letter from external Research Ethics Committee		Yes ☐
c.	The proposal ('case for support') for the project		Yes ☐
d.	Full risk assessment		Yes ☐

Section 10 Declaration

I confirm that to the best of my knowledge the information in this form is correct and that this is a full description of the ethical issues that may arise in the course of this project.

I have discussed the ethical issues relating to my research with my supervisor. ☒ ☐

I have attended the appropriate ethics training provided by my course. ☒ ☐

I confirm that to the best of my knowledge:

The above information is correct and that this is a full description of the ethics issues that may arise in the course of this project.

Name	Justin Kit-yan Chu
Date	22 Sept 2019

Please submit your completed ethics forms to your supervisor for review.

Notes and references

Professional code of ethics

You should read and understand relevant ethics guidelines, for example:

British Psychological Society (2009) *Code of Ethics and Conduct*, and (2014) *Code of Human Research Ethics*

or

British Educational Research Association (2011) *Ethical Guidelines*

or

British Sociological Association (2002) *Statement of Ethical Practice*

Please see the respective websites for these or later versions; direct links to the latest versions are available on the Institute of Education http://www.ucl.ac.uk/ioe/research/research-ethics

Disclosure and Barring Service checks

If you are planning to carry out research in regulated Education environments such as Schools, or if your research will bring you into contact with children and young people (under the age of 18), you will need to have a Disclosure and Barring Service (DBS) CHECK, before you start. The DBS was previously known as the Criminal Records Bureau (CRB) . If you do not already hold a current DBS check, and have not registered with the DBS update service, you will need to obtain one through at IOE.

Ensure that you apply for the DBS check in plenty of time as will take around 4 weeks, though can take longer depending on the circumstances.

Further references

The www.ethicsguidebook.ac.uk website is very useful for assisting you to think through the ethical issues arising from your project.

Robson, Colin (2011). *Real world research: a resource for social scientists and practitioner researchers* (3rd edition). Oxford: Blackwell.

This text has a helpful section on ethical considerations.

Alderson, P. and Morrow, V. (2011) *The Ethics of Research with Children and Young People: A Practical Handbook.* London: Sage.

This text has useful suggestions if you are conducting research with children and young people.

Wiles, R. (2013) What are Qualitative Research Ethics? Bloomsbury.

A useful and short text covering areas including informed consent, approaches to research ethics including examples of ethical dilemmas.

Departmental use

If a project raises particularly challenging ethics issues, or a more detailed review would be appropriate, the supervisor **must** refer the application to the Department Research Ethics Coordinator (via ioe.researchethics@ucl.ac.uk so that it can be submitted to the Research Ethics Committee for consideration. A departmental research ethics coordinator or representative can advise you, either to support your review process, or help decide whether an application should be referred to the REC. If unsure please refer to the guidelines explaining when to refer the ethics application to the IOE Research Ethics Committee, posted on the committee's website.

Student name	Justin Kit-yan Chu

Student department	Curriculum, Pedagogy and Assessment	
Course	Doctor of Education (EdD)	
Project title	Student engagement in first-year university biology: Teachers' perspectives on their approaches to support engagement	
Reviewer 1		
Supervisor/first reviewer name	Dr Jennie Golding	
Do you foresee any ethical difficulties with this research?		
Supervisor/first reviewer signature		
Date		
Reviewer 2		
Second reviewer name		
Do you foresee any ethical difficulties with this research?		
Supervisor/second reviewer signature		
Date		
Decision on behalf of reviews		
Decision	Approved	☐
	Approved subject to the following additional measures	☐
	Not approved for the reasons given below	☐
	Referred to REC for review	☐
Points to be noted by other reviewers and in report to REC		
Comments from reviewers for the applicant		

Once it is approved by both reviewers, students should submit their ethics application form to the Centre for Doctoral Education team: IOE.CDE@ucl.ac.uk.

Appendix 5.2 EdD ethics application form – minor amendment

Institute of Education UCL

Notice of amendment to previously approved IOE PGR research project

This form is designed for **EdD and MPhil/PhD students** at the UCL Institute of Education who have **previously obtained ethical approval** for their research, and who now need to **amend their data collection methods** in light of COVID-19-related disruption.

You should read the **guidance on moving on to online data collection**, which is circulated with this form.

When you have completed this form, please **email it to your supervisor** along with any amended participant-facing documents such as information sheets and consent forms, **and** your original ethical approval form. The supervisor will then review and, if appropriate, suggest further amendments. When s/he approves the amendments, s/he will sign the form electronically and return it to you.

When the form is complete and signed by your supervisor, please email it, along with the amended instruments, to IOE.CDE@ucl.ac.uk **and** data-protection@ucl.ac.uk. Use the subject line **Notice of amendment to IOE PGR research project**

Section 1 – Project details

a. Project title	Student engagement in first-year university biology: Course tutors' perspectives on their approaches to support engagement
b. Student name	Justin Kit-yan Chu (16135937)
c. Project reference (REC code, if known)	Enter text
d. Your department	Curriculum, Pedagogy and Assessment

Section 2 - Care for participants and researchers

Please make brief notes on how you will address care for participants and for yourself as researcher in the change to online research given the particular context of your participants

Since the data collection has been ongoing, participants will be contacted to advise them that the interviews will be changed to online, and check if they are happy to continue with the study. This is done by sending them a modified Information Sheet and Consent Form that detail the online interviews. Before the start of the interview, I will tell my participants that I am in a private environment where no one, other than the participant, can hear the conversation so that their privacy is maintained. I will also ask if the participants if they are comfortable for the interview again. Then, with their permission, I will start recording the interview. During the interview, I will be aware of any signs, such as their facial expression or body language, that the participants may feel a sense of discomfort, intrusion or coercion. I will remind the participants that they can reject answering any questions or stop the interview if they feel uncomfortable, and no reasons will be asked for.

Section 3 - Secure online data collection

If your research involves **online interviews or focus groups** how will you conduct this and address the issues in the guidance?

<u>Online Interviews</u>
The online interviews will be conducted via the UCL preferred app – Microsoft Teams. Participants will be informed via the Information Sheet and Consent Form that the interview will be video and audio recorded, and their consent will be gained.

If your research involves **online surveys and/or questionnaires** how will you conduct this and address the issues in the guidance?
N/A

Section 4 – Data management and security

Please see the guidance, and note how you will engage with storing and managing your data securely

Anonymised data will be stored on encrypted password-protected UCL S-Drive and N-Drive and transferred from password protected recorders. Recordings will be deleted once transferred to laptops. Only the researcher myself will have access to the names associated with data in consent forms, and any related data will be anonymised.

Section 5 – Signature of supervisor

I have reviewed the amendments and approve these changes to the data collection methods.

Name
Dr Jennie Golding
Signature
Jennie Golding
Date
13.05.20

Appendix 6 - Samples of Transcripts

1.

Transcript	Code
Teacher A: When it comes to helping students learn, I've found that it's really effective to break down the information into smaller, more manageable parts. Instead of bombarding them with heaps of stuff all at once, I like to give it to them in bite-sized pieces. That way, they can focus on one thing at a time, and it's much easier for them to understand and remember the material.	Breaking down complex concepts
Interviewer: That's a great strategy. You've mentioned chunks of information. Can you tell me more about managing chunks in online learning?	
Teacher A: Sure. Chunking is all about organising things in a way that makes it easy for students to navigate through their learning materials. Especially in an online environment, it's super important to structure the content into logical sections or modules. This way, students can easily follow the course flow and find the information they need without any hassle. Breaking things down into manageable chunks also helps students absorb the material more effectively, without feeling like they're drowning in a sea of information. It's all about keeping things organised and easily digestible for their learning journey.	Breaking down complex concepts
Interviewer: So, tell me more about how you use Canvas as a platform for chunking as a way to engage students.	
Teacher A: What I like to do is organise the course content into modules or pages, each one dedicated to a specific topic or theme. And within each module, I take it a step further and break down the content into smaller, more manageable sections. I include various types of learning resources like readings, videos, mini-presentations, simulations, and interactive quizzes. This way, students can easily navigate through the course materials and keep track of their progress along the way. It's all about providing them with a clear structure and easy access to the different components of their learning experience.	Canvas as a platform for chunking
Interviewer: That sounds like a well-structured approach. What other resources and activities do you use to support online learning?	
Teacher A: In addition to the chunked content on Canvas, I've added various resources and activities to enhance online learning. I include short video clips to provide visual explanations, readings to deepen their understanding, mini-presentations to summarise key points, simulations to engage students in practical applications – not too many can be found online though, and quizzes to assess their understanding. So these diverse resources cater to different learning styles and help maintain student engagement. So these could be pre-tutorial learning activities. Before each live tutorial or discussion session, I assign pre-readings or pre-recorded videos related to the upcoming topic. This allows students to familiarise themselves with the concepts beforehand, ensuring they come to the session prepared. It also sets the foundation for more meaningful discussions and interactions during the live sessions.	Videos, readings, mini-presentations, simulations, interactive quizzes Pre-tutorial learning activities
Interviewer: That's a great approach to prepare students for the live sessions, maximising effectiveness. Do you have other strategies?	

Teacher A: So here's what I do: I break down the concept into different sections or subtopics. Once I've identified the main components of the complex concept, I create checkpoint activities for each section. These activities serve as checkpoints or mini-assessments for students to gauge their understanding before moving on to the next part. These checkpoint questions are like the backbone of my online courses. I strategically sprinkle them throughout the modules or every few pages on Canvas to get students to show what they've learned and reflect on it. I mix things up, using short quizzes, self-assessments, or open-ended prompts as the checkpoint questions. The main goal of these questions is to make sure students are getting the hang of the material and retaining it as they go through the course. Plus, these quizzes also help them review what they've learned and give them immediate feedback. That way, they can spot any areas that need more attention and work on them. It's all about active learning, you know, where they're really engaged, and it also helps me keep tabs on how well they're understanding the content.	Checkpoint questions/ Interactive quiz questions Automated feedback in the form of videos or writing

2.

Transcript	Code
Interviewer: What other strategies have you used to engage students in online learning?	
Teacher B: I always believed hands-on activities are essential. They make students get involved and really understand things deeply. So, we had this investigation about osmosis. It's all about how water moves through selectively permeable membranes. I asked students to get some simple things like eggs, salt, vinegar, and different sugars to do the investigations. Just things you can find in your kitchen, no worries at all! By conducting this experiment at home, students were able to see firsthand how osmosis works and gain a practical understanding of the concept.	Hands-on activities Home experiments
Interviewer: That's a fantastic approach! Do you have other similar examples that could be hands-on for students to do during online learning?	
Teacher B: Oh, let me tell you about this amazing lesson I designed! So, I wanted my students to really grasp how different joints work in our bodies and affect our movements. I came up with this fun activity where I had them all stand up in front of their computers, in that anatomical position you know, and I made sure they were away from the camera. Then, I guided them through different movements, and here's the best part – each student had to perform one movement and get their classmates to describe it and the joints involved. It was so hands-on and interactive! The students were physically involved, and they actively participated in the whole learning process. It was such a fantastic way to bring the topic to life!	Movement-based exercises Physical demonstrations
Interviewer: That sounds like a great way to involve students and make learning interactive. Could you provide another example of a hands-on activity that you implemented?	
Teacher B: Certainly. So, here's what I did: I wanted my students to understand how pollen and seeds are adapted for dispersal, you know, their structure and all. So, I asked them to create their own physical models using everyday materials they could find at home. They got to use things like paper, tape, and other craft supplies to build these awesome models. Then, during our virtual class session, each student presented their model to the rest of the class. It was	Physical demonstrations

fantastic! Not only did they get to explore the concept of structural adaptation in a hands-on way, but they also had the chance to practice their presentation skills and learn from their peers. It was such a great way to make the lesson interactive and fun!	
Interviewer: That's a wonderful approach to promote hands-on learning and practical application. Lastly, how do you ensure students have done those tasks, home experiments for example?	
Teacher B: You see, I believe it's super important for them to document their progress and show what they've learned. That's why I always encourage my students to use a Discussion Forum to share their work with each other. It's like this virtual space where they can have discussions and show off what they've been up to. They can write down their thoughts, share photos, videos, or even record their voices, depending on what they've been working on. It's really cool because it's so interactive! Now, to make sure everyone knows what to do, I give them clear guidelines and tell them exactly how to document and submit their work on the Discussion Forum. This way, they can show their learning journey in the best possible way and have meaningful conversations with their classmates. It becomes a place where they can collaborate, learn from each other, and celebrate all the awesome things they've achieved.	Record activities

3.

Transcript	Code
Interviewer: In your live lesson, I could see that you have used different prompts or hints and support to encourage meaningful discussions and collaboration among students. Could you tell me more about this?	
Teacher B: Yeah, that was a good problem-solving, collaborative exercise. It really stimulates students to think. I provided video clips to enhance their understanding of the concepts being discussed or sometimes the video just illustrates the problem itself. As you can see in the worksheet, guided questions and hints, oh yeah, they're really important, you know? They help students think and bring out different ideas during group work. These resources, like little prompts, make students look at things from different angles. They encourage them to think outside the box and really dive deep into the topic we're studying.	Cognitive inputs (e.g video clips, diagrams, hints) Selecting relevant areas/aspects for discussion
Interviewer: That's a fantastic approach to promote effective collaboration. I saw you unpack the main problem or topic in the lesson to facilitate in-depth discussions. Could you elaborate more?	
Teacher B: Oh, unpacking the main problem or topic is so important to get those in-depth discussions going, you know? What I do is break down those complex concepts or issues into smaller parts or sub-topics, step by step. I guide my students through the whole process. I might start by giving them some background information, asking them thought-provoking questions, or sharing relevant resources. It's all about gradually unpacking the topic, helping them gain a deeper understanding. And you know what? I also love using diagrams. They're such powerful visual tools! I use diagrams to show how things relate to each other, the processes involved, or even the structures we're studying. During our virtual class sessions, I share these visual representations with my students, and sometimes I give them interactive diagrams to explore on their	Unpacking the main problem/ Stimulating thinking Cognitive inputs (e.g video clips, diagrams, hints)

own. It's amazing how these visuals help them picture those abstract concepts and really strengthen their understanding of the subject matter.	
Interviewer: That's a great way to facilitate comprehension of the problems and make sure the discussion and collaboration are effective. In the lesson, I saw students have to report their discussion on a template. Could you elaborate on the function of the report template?	
Teacher B: The report template is like a proforma for recording and reporting outcomes, but in a more student-friendly way! It's right there on Canvas, in the format of Google Docs. The beauty of it is that everyone can edit it at the same time, so it's super collaborative. With this clear structure in place, my students can stay focused on the important elements. Plus, it encourages them to really reflect critically on their findings and thoughts. And the best part is when they present their outcomes, everything looks so organised and consistent. It's a win-win!	Proforma for recording and reporting outcomes
Interviewer: That's a great approach to use the proforma to maximise engagement and interaction among students during the activity.	

4.

Transcript	Code
Interviewer: Can you tell us more about the lessons about aligning the learning outcomes of the subject to students' future work and study?	
Teacher A: Setting study goals is a really important part of helping students on their learning journeys. I always encourage my students to think about their career aspirations and how the subjects we study can actually contribute to their future goals. In that lesson, I really wanted them to understand why learning the subject would benefit their future studies. So, I put up a list of their second and third-year subjects from their study plan right on the screen. We went through the definitions of each subject, like haematology, which is all about the study of blood. And then, using Zoom's poll system, I asked them to identify which subjects would benefit from having a solid foundation in cell biology, the subject we were currently studying. It was a really interactive exercise that helped them see just how relevant and useful what they were learning could be for their future studies and careers.	Subject relevance to future learning and future career / Study goals
Interviewer: So that's a great start for students to visualise the connection between the subject and their future. What else do you do to make subject matter relevant to your students' future learning and careers?	
Teacher A: It's absolutely crucial to make the subject matter relevant to our students' future learning and careers. One of the ways I do this is through the discussion forum. I post questions that really make them think about how the concepts and skills they're learning now form a solid foundation for their future studies and careers. It's all about helping them see the bigger picture and how what they're learning now will actually benefit them down the road. I also make a point to discuss potential career paths that are related to the subject we're studying. I highlight how mastering the content will be valuable in those fields and open up exciting opportunities for them. By giving them that glimpse into the future, they can really see the practical applications of what they're learning and	Subject relevance to future learning and future career / Career goals Meaningful and personal

understand the importance of their efforts. And you know what? In the past, I've even gone the extra mile and invited guest speakers from relevant professions to share their experiences and insights with the students. It's amazing how hearing from someone in the field can ignite their curiosity and give them a real-world perspective. These guest speakers provide valuable context and inspiration, further connecting the subject matter to their future aspirations. By making these connections and showing them the relevance, I'm able to create a sense of purpose and excitement among my students, encouraging them to invest more in their studies.	relevance

5.

Transcript	Code
Interviewer: So how do these direct, first-hand experience translate into your self-efficacy in online teaching?	
Teacher B: I guess it is the reflective journal that I kept. Reflective journaling played a significant role in building my self-efficacy in online teaching. I think reflection is really important for personal growth. That's why I keep a notebook where I write down my thoughts and reflect on my teaching. It helps me see any flaws or weaknesses in my materials. I can pinpoint areas that need improvement and make the necessary adjustments. It's a valuable tool for me to become a better teacher.	Reflective journaling Growing confidence through reflection Identifying areas of improvement
Interviewer: That's an excellent practice. What does the reflective journals capture?	
Teacher B: I've got this journal that helps me a lot in reflecting on my teaching practice. It's my tool every week. At the end of each week, I sit down, grab a cup of tea, and take a moment to assess how my online activities and lessons went. I really try to be honest with myself and identify areas where I can improve. And let me tell you, it's a continuous process of learning and growing. There were times when I noticed some activities didn't work out as well as I hoped. One example was this online discussion activity that didn't quite spark much participation. It got me thinking, and after some deep reflection, I realized the prompt I provided just wasn't cutting it. It wasn't engaging enough to get my students excited and involved. So, I decided to give it a makeover! I spiced things up by adding multimedia elements like videos and images to make it more eye-catching and thought-provoking. And I didn't stop there. I also revised the prompt itself, making it more open-ended and encouraging diverse perspectives. And it made a world of difference! The students started to really engage, and we had some fantastic and meaningful discussions. It was such a proud moment for me. It just goes to show that reflection and making those little adjustments can have a big impact on student engagement and learning.	Weekly reflections on teaching practice/ Evaluation of activity success Identifying areas of improvement Transforming less successful activities
Interviewer: Can you show me that Discussion Activity on the screen later? Thanks.	
Teacher B: Sure. I want to add something as well. I also took some time to visualize those successful strategies that really worked like a charm in my online classes. It's like reliving those moments when everything just clicked. I remember those instances when my students were actively engaged, participating, and showing a deep understanding of the content. It's those moments that made me	Visualization of successful strategies

feel like, "Yes, I'm making a difference!" Visualising those successful moments played a huge role in boosting my confidence as an online teacher. It reminded me that I'm capable of creating effective instructional approaches that resonate with my students. It's like a little pat on the back.	

6.

Transcript	Code
Interviewer: Moving on to the next source of self-efficacy – social persuasion. It is about what other people have said about your teaching. Of the things that people had said, which ones stand out for you that have influence on your self-efficacy in online teaching?	
Teacher A: Absolutely. During the ERT, I found that informal sharing with my teenage daughters played a significant role in boosting my self-efficacy as an online teacher. They have been my "guinea pigs" for the online course I'm developing. I often discuss my teaching ideas and strategies with them, and they provide valuable feedback. Since they are teenagers themselves, their insights into what works well and what needs improvement are incredibly valuable. Their opinions matter because they represent the perspective of typical teenagers.	Informal sharing with teenage daughters Seeking feedback and evaluation
Interviewer: That's interesting. How did their early feedback impact your self-efficacy?	
Teacher A: Their early feedback played a huge role in boosting my confidence as an online teacher. When I started trying out new teaching methods, they were the ones who gave me feedback right away. They pointed out what parts of my approach were engaging and effective, and also highlighted areas that needed improvement. Their input was invaluable in fine-tuning my teaching methods and making the necessary adjustments. It felt amazing to know that I was creating a course that truly connected with them and it gave me a real sense of accomplishment. Their feedback definitely boosted my confidence and self-efficacy in online teaching.	Daughter's early feedback as critical Seeking feedback and evaluation
Interviewer: It's great to hear that their input made a difference. How did you incorporate their feedback into your teaching practice?	
Teacher A: I made sure to ask them for their feedback after every lesson or activity. We would sit down together and have a chat about their experience as students in my online course. They were always honest with me, sharing their opinions and giving suggestions on how I could improve. Their feedback was like a compass guiding me in refining the course content, instructional design, and how we interacted during the lessons. I took their input seriously and made changes based on what they said, so that the course would be a better fit for teenage learners like them. Their constructive feedback really helped me grow as an online teacher and made the overall learning experience even better.	Seeking feedback and evaluation
Interviewer: That sounds like a valuable learning process. Thank you.	

Appendix 7 Summary of the findings of the thematic analysis

Phase 1 – Codes	Phase 2 – Categories	Phase 3 – Theme generated	Phase 4 – Themes revised and mapped? Under the theory
• Breaking down complex concepts • Managing chunks • Physical classrooms vs. online learning • Canvas as a platform for chunking • Videos, readings, mini-presentations, simulations, interactive quizzes • Pre-tutorial learning activities • Checkpoint questions • Interactive quiz questions	• Dividing multi-part, complex concepts into pieces • Sequencing or arranging the mini concepts in a logical order • A chunk that can be understood independently before integrating them together • Making completion of each piece as success • Checkpoints and feedback	Chunking complex concepts into manageable pieces with checkpoint activities	**Competence-supportive strategy for sustaining concentration:** Chunking and checkpoints (Theme 1.1)
• Complex concepts explained by students • Physical classroom vs. breakout rooms in Zoom • Pairs of students teaching each other • Teacher's presence and assistance in breakout rooms • Peer-evaluation • Monitoring Progress	• Actively explaining complex concepts • Working in small groups • Peer monitoring and evaluation	Students working in pairs to explain complex concepts to each other, and their explanations are evaluated.	**Competence-supportive strategy for sustaining concentration:** Deliberate rehearsal of concepts (Theme 1.2)
• Adapting materials for online learning • Integration of information • Reducing attention split • Modifying graphs and annotations	• Reorganising information by changing the order, arrangement, or grouping of ideas to enhance clarity and coherence • Condensing or summarising complex information into concise and digestible	Reorganising information for a clearer presentation	**Competence-supportive strategy for sustaining concentration:** Information reorganisation (Theme 1.3)

Phase 1 – Codes	Phase 2 – Categories	Phase 3 – Theme generated	Phase 4 – Themes revised and mapped? Under the theory
• Labeling information for reference • Simplifying and clarifying instructions • Clear focus on learning concepts	chunks to facilitate understanding		
• Hands-on activities • Movement-based exercises • Physical demonstrations • Home experiments • Record activities	• Physical objects or manipulatives that learners can use or interact • Experiments through video recordings or live sessions, allowing learners to observe and engage with the content	Embedding kinaesthetic activities in online learning	**Competence-supportive strategy for sustaining concentration:** Kinaesthetic activities (Theme 1.4)
• Lack of knowledge about Zoom functions • Essential functions of Zoom • Importance of visual communication • Future relevance and success in work and study • Demonstration • Guided Practice • Tool Exploration • Support (e.g., troubleshooting)	• demonstrating the various online collaborative tools available • opportunities for students to explore and navigate different online collaborative tools • students actively using online collaborative tools to work together	Familiarising students with the online collaborative tools	**Competence-supportive strategy for effective collaboration:** Online collaborative tool familiarisation (Theme 2.1)
• Importance of students realising the benefits themselves • Use of reflection to understand the benefits • Reflection task after collaborative activity • Brainstorming reasons for	• Fostering a positive and supportive classroom or online environment that values and encourages collaborative learning among students • Sharing experiences allow students to gain new insights and broaden their understanding	Explicit promotion of the benefits of collaborative learning	**Competence-supportive strategy for effective collaboration:** Promoting the benefits of collaborative learning (Theme 2.2)

Phase 1 – Codes	Phase 2 – Categories	Phase 3 – Theme generated	Phase 4 – Themes revised and mapped? Under the theory
collaboration • Elaboration on the benefits of collaboration • Comparing and contrasting contributions by different peers • Motivating students to participate in collaborative activities	• Providing opportunities for active participation, meaningful interactions, and a sense of ownership in the learning process.		
• Active monitoring • Debriefing collaborative activities • Purposeful praise for individuals or groups • Facial expressions indicating encouragement, recognition, and pride • Boosting student competence through noticing and praising	• Actively observing their contributions, interactions, and level of involvement • Specific feedback to students on their contributions and performance • Appreciating students' collective efforts and achievements in collaborative tasks, fostering a positive and supportive learning community	More noticing of individual students' contribution and performance in collaborative tasks	**Competence-supportive strategy for effective collaboration:** More noticing of students' contribution and performance in collaborative tasks (Theme 2.3)
• Cognitive inputs (video clips, descriptions of scenarios, sub-questions, hints) • Guided questions • Diagrams • Proforma for recording and reporting outcomes • Time for preparation and discussion • Extending collaborative and discussion time • Unpacking the main problem • Stimulating thinking • Selecting relevant areas/aspects for	• Providing resources, including time for preparation, unpacking the tasks, cognitive inputs as stimulants, platform for documenting the discussion.	Providing adequate resources for a fruitful collaboration	**Competence-supportive strategy for effective collaboration:** Resources for a fruitful collaboration (Theme 2.4)

Phase 1 – Codes	Phase 2 – Categories	Phase 3 – Theme generated	Phase 4 – Themes revised and mapped? Under the theory
discussion • Encouraging meaningful and substantive discussions			
• Language tips (e.g. asking open-ended questions, summarizing key points, encouraging diverse perspectives) • Designated leader • Flow of discussion • Free riders • Structured and balanced discussions • Modeling Effective Discussion	• Facilitation techniques to support productive discussions • Assigning specific roles or responsibilities within discussions, ensuring equal participation. • Modeling effective discussion techniques and behaviors for students	Providing students with discussion support for effective collaboration	**Competence-supportive strategy for effective collaboration:** Discussion support for effective collaboration (Theme 2.5)
• Same group members • Limited opportunities for making friends and connections online • Tracking group membership on Canvas • Displaying group members on the screen • Exchanging contact information for social media connections • Form bonds • Uncomfortable feeling with randomly assigned groups • Lack of familiarity and control with random peers • Difficulty in effective collaboration with unfamiliar members	• Consistent group membership promotes collaboration by allowing students to form bonds and develop familiarity and control within their groups • Tracking group membership on Canvas • Social media connections facilitating ongoing interaction and support among group members	Maintaining the same group members in every collaborative activity	**Relatedness-supportive strategy for effective collaboration:** Same group members throughout the semester (Theme 2.6)

Phase 1 – Codes	Phase 2 – Categories	Phase 3 – Theme generated	Phase 4 – Themes revised and mapped? Under the theory
• Alignment with daily life events • Study goals • Career goals • Subject relevance to future learning and future career • Meaningful and personal relevance • Goal setting and engagement in learning	• Making connections between classroom concepts and students' lives, interests, or future aspirations • Topics, projects, or activities that align with their interests, goals, or experiences • Authentic tasks or projects that reflect real-life situations, challenges, or scenarios, allowing students to apply their knowledge and skills in meaningful ways	Fostering relevance to students	**Autonomy-supportive strategy for independent learning:** Fostering relevance (Theme 3.1)
• Flexible learning • Self-Paced learning • Blended learning • Varied assessment formats • Access to Resources and Materials	• Flexibility to learn at their own pace • Explore different topics, approaches, or resources based on their preferences and needs • A mix of online and offline learning modalities, allowing students to choose the methods that work best for them • Options for demonstrating their learning through various assessment formats • Ensuring that students have access to a variety of resources and materials	Offering choices on how, when and where to learn	**Autonomy-supportive strategy for independent learning:** Offering choices (Theme 3.2)
• Timely and formative Feedback • Individualised Feedback • Automated feedback in the form of videos or writing	• providing ongoing feedback to students in a timely manner • tailoring feedback to meet the individual needs • utilizing digital tools and platforms that enable efficient and effective feedback delivery	Providing feedback to students where feasible	**Autonomy-supportive strategy for independent learning:** Providing timely feedback (Theme 3.3)

Phase 1 – Codes	Phase 2 – Categories	Phase 3 – Theme generated	Phase 4 – Themes revised and mapped? Under the theory
• Reflection Prompts and Questions • Reflections • Goal Setting and Action Planning • Technology Tools for Reflection • Sharing strengths and weaknesses for goal setting • Weekly confidence checklist • Broadening thinking through reading others' feedback	• promoting self-awareness and evaluation of student learning journey • tracking student development and take proactive steps towards improvement • enhancing students' reflective abilities	Promoting self-reflective practice	**Autonomy-supportive strategy for independent learning:** Promoting self-reflective practice (Theme 3.4)

Phase 1 – Codes	Phase 2 – Categories	Phase 3 – Theme generated	Phase 4 – Themes revised and mapped? Under the theory
• Face-to-face to online strategy adaptation • Confidence in cross-medium effectiveness • Strategies applicable in different scenarios • Importance of online collaboration support • Improved self-efficacy through successful strategies	• Pre-ERT motivational strategies • ERT motivational strategies • Impact and effectiveness of motivational strategies	• Experiences in using motivational strategies before and during the ERT • Experiences in designing engaging resources online	**Mastery Experiences** • Direct experiences in using motivational strategies before and during the ERT • Direct experiences in designing engaging resources online
• Online tools for engaging learning materials • Canvas • Empowerment and confidence in online teaching • Enhancing asynchronous learning with visual aids • Improving student understanding through interactive elements • Experiences shaping self-efficacy in online teaching.	• Adapting resources for online delivery • Incorporating multimedia and interactive elements • Promoting active learning and student engagement • Addressing diverse learning needs and preferences • Assessing the effectiveness of online resources	• Experiences of monitoring student engagement and achievement online	• Direct experiences of monitoring student engagement and achievement online
• Student engagement monitoring • Online tools for understanding engagement • Tracking time and page views on Canvas • Monitoring participation, emotions, and	• Student Engagement Monitoring: • Online Tools for Understanding Engagement • Analytics for Engagement Analysis	• Teachers being reflective as part of the mastery experiences	• Teachers being reflective as part of the mastery experiences

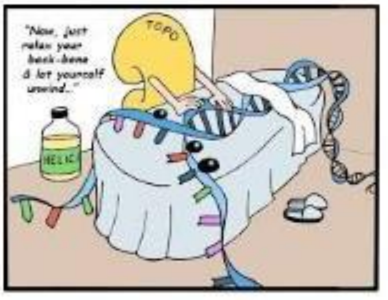
Phase 1 – Codes	Phase 2 – Categories	Phase 3 – Theme generated	Phase 4 – Themes revised and mapped? Under the theory
academic development • Analysing video, resource, and quiz performance • Providing evidence of engagement through analytics	• Reflective Practices • Activity Evaluation and Improvement • Visualization and Confidence Building		
• Auditing lessons taught by colleagues • Context and nature of exemplars • Boosting self-efficacy through observing others' success • Observing similar teaching contexts • Drawing inspiration from colleagues in the same subject • Considering student composition and subject-specific pedagogy • Confidence through practice-related sharing and successful strategies	• Contexts (teachers/students/subjects) • The practice-nature of exemplars	• Contexts (teachers/students/subjects) are key to vicarious experience • The practice-nature of exemplars is key to vicarious experience	**Vicarious experiences** • The importance of contextual elements • Practice-focused professional development
• Informal sharing with teenage daughters • Seeking feedback and evaluation • Daughter's early feedback as critical • Sharing Canvas course with colleagues • Seeking feedback and evaluation • Professional dialogues and discussions	• Verbal persuasion from family members • Verbal persuasion from colleagues	• Verbal persuasion from family members • Verbal persuasion from colleagues	**Verbal persuasion** • Respectable persons: Family members • Knowledgeable others: Colleagues

Phase 1 – Codes	Phase 2 – Categories	Phase 3 – Theme generated	Phase 4 – Themes revised and mapped? Under the theory
• Pandemic-related sadness and loneliness • Recognizing advantages of online teaching • Valuing mental health and well-being • Stronger bond with family members • Confidence and courage derived from feedback • Feeling stressed and urgent during COVID • Displaying appreciation cards for positive environment • Recognizing benefits of online education • Seeing online teaching as a new skill set • Confidence in effectiveness as a teacher	• Addressing negative emotions • Focusing on positive emotions	• Addressing negative emotions • Focusing on positive emotions	**Emotional states** • Addressing negative and focusing on positive emotions
• Deep enthusiasm for teaching • Belief in the power of education • Determination to inspire and support students • Revamping online teaching design and materials • Active engagement during synchronous sessions • Professional development and sharing • Engaging in professional development	• Love for teaching • Investment in teaching design and materials • High level of engagement	• Enthusiastic and passionate	• Passion

Phase 1 – Codes	Phase 2 – Categories	Phase 3 – Theme generated	Phase 4 – Themes revised and mapped? Under the theory
activities • Staying updated with online education trends and advancements • Passion fueling teacher motivation • Instilling a sense of purpose in their work			
• Learning new technologies • Overcoming technical glitches • Adapted online pedagogy: • Modifying strategies from pre-ERT era • Tailoring strategies to meet student needs • Openness to innovation and change • Flexibility and adaptability • Resolving challenges through adaptation • Being flexible and open-minded	• Flexible and Adaptive • Openness	• Suit changing conditions	• Adaptability
• Reflective journaling • Weekly reflections on teaching practice • Identifying areas of improvement • Evaluation of activity success • Transforming less successful activities • Visualization of successful strategies	• giving careful thought to online teaching experience	• Reflection	• Being reflective

Appendix 8 - Artefacts collected

Week #9 - DNA Replication



For additional study on DNA replication, refer to:-

- Chapter 16 of your textbook
- The attached videos

DNA Replication The Cell's Extreme Team Sport.mp4

DNA replication - 3D.mp4

DNA Replication.mp4

Semiconservative Replication.mp4

Topoisomerase 1 and 2.mp4

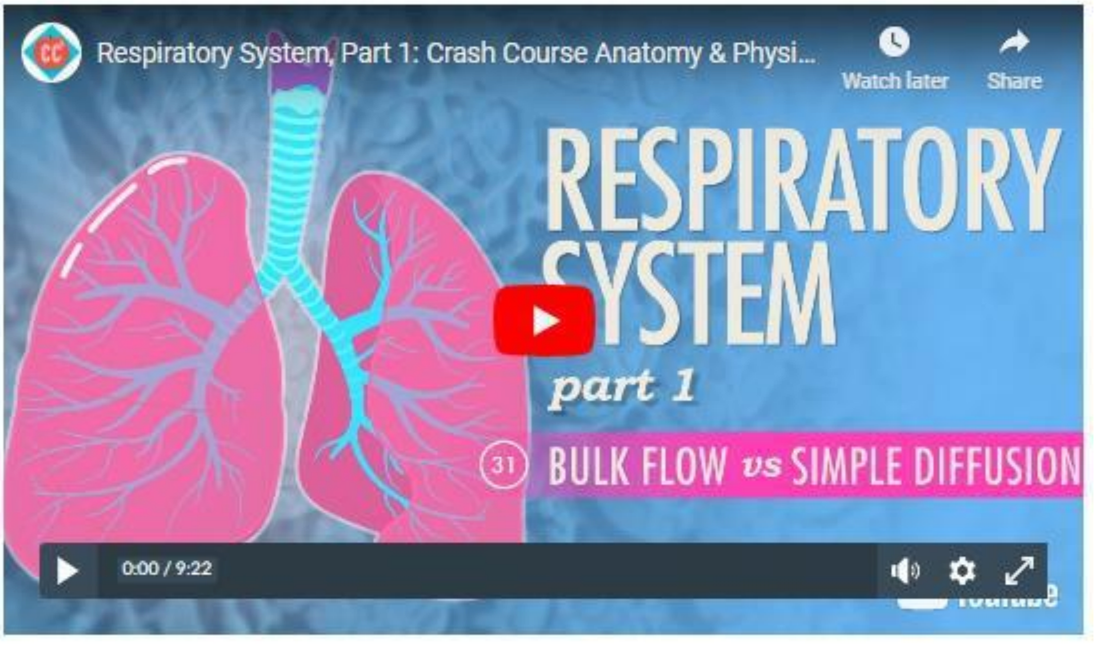
Theme 1.1

Before ERT, teachers had already built some pages on Canvas to unpack a difficult concept

Week 7 Pre-class activities

Please watch the below videos for this week:

Video 1:



Video 2:

⮙ Theme 1.1

Before ERT, teachers had already built some pages on Canvas to unpack a difficult concept

Week 3

Lipids

We will focus on lipids. These are a diverse range of biomolecules. They have functions in energy storage and are a key component of the plasma membrane. They also comprise cholesterol, steroids, and vitamin D. We look at the structure and function of all these lipids.

Readings

Biology 2e Lipids

OpenStax

Reading

Allow 15-20 minutes

This reading discusses the fundamental aspects of lipids: their structural differences, significance, and functions.

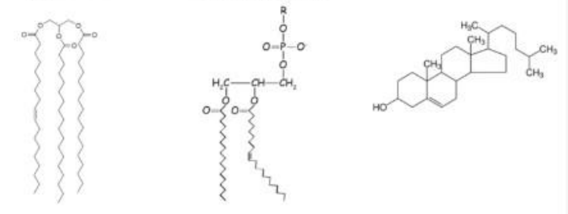
As you read this article, annotate your key concept notes.

Activity

Edit | Reports

Lipids There are 3 fundamental types of lipids.

Triglycerides | Phospholipids | Steroids



2 / 25

Reuse

Transcript

Discuss

Amenorrhea is the absence of menstruation. This can happen in female athletes like gymnasts and ballerinas because they have a very low body fat content.

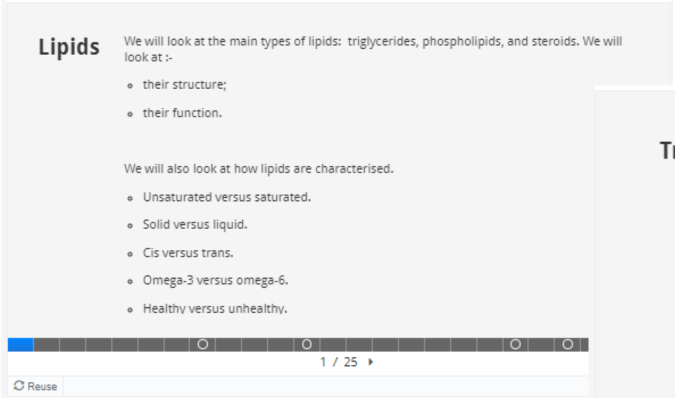
- Using what you've learned about steroids, deduce the reasons.

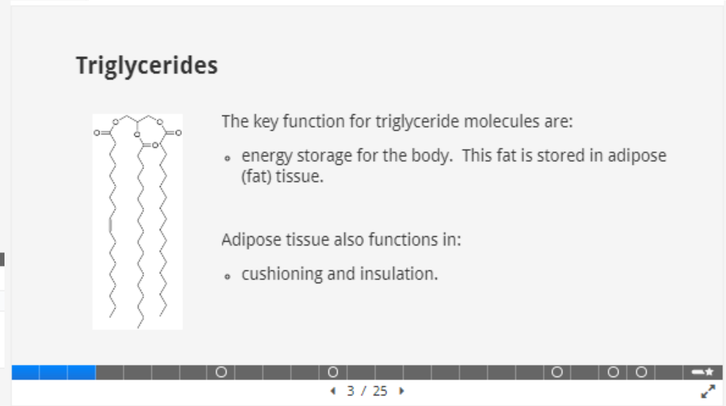
Post your responses on the Q&A discussion forum. Active participation in these discussions forms part of your Assessment.

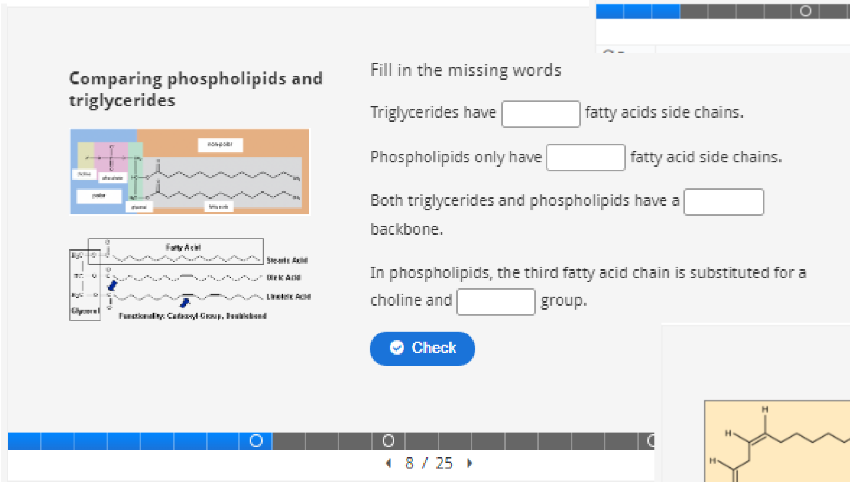
Week 3: Q&A Discussion Forum

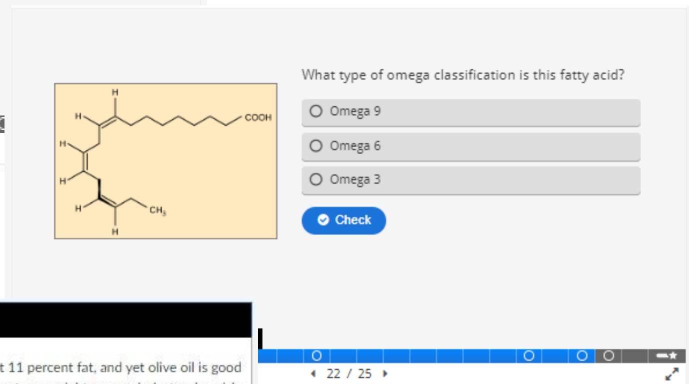
Theme 1.1

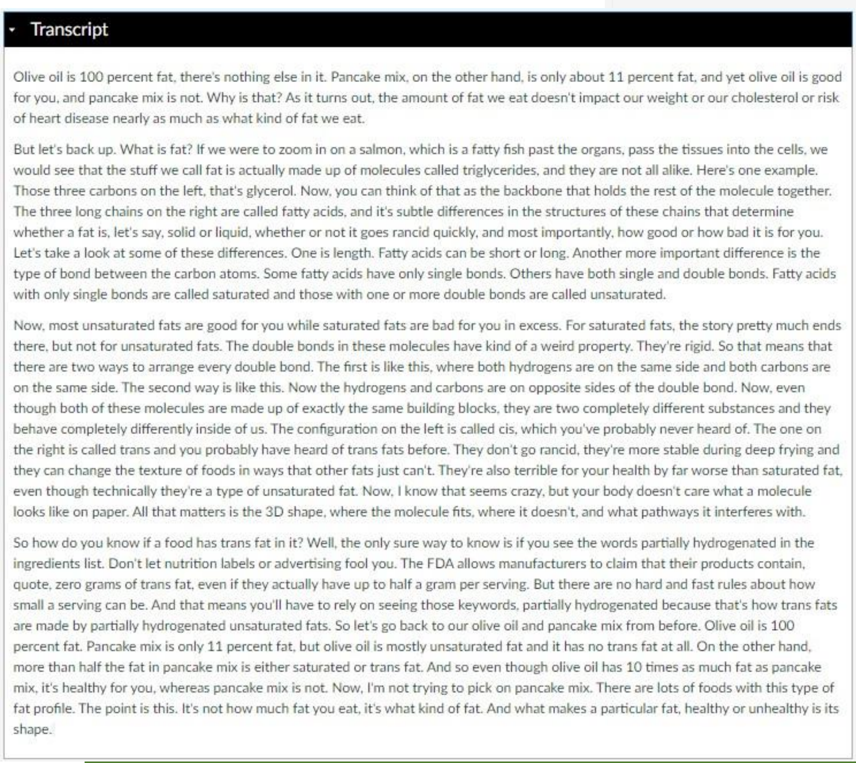
When teacher A introduced the biochemistry of lipids, she designed pre-tutorial learning activities that required students to understand the basic structure and function of lipids











Transcript

Olive oil is 100 percent fat, there's nothing else in it. Pancake mix, on the other hand, is only about 11 percent fat, and yet olive oil is good for you, and pancake mix is not. Why is that? As it turns out, the amount of fat we eat doesn't impact our weight or our cholesterol or risk of heart disease nearly as much as what kind of fat we eat.

But let's back up. What is fat? If we were to zoom in on a salmon, which is a fatty fish past the organs, pass the tissues into the cells, we would see that the stuff we call fat is actually made up of molecules called triglycerides, and they are not all alike. Here's one example. Those three carbons on the left, that's glycerol. Now, you can think of that as the backbone that holds the rest of the molecule together. The three long chains on the right are called fatty acids, and it's subtle differences in the structures of these chains that determine whether a fat is, let's say, solid or liquid, whether or not it goes rancid quickly, and most importantly, how good or how bad it is for you. Let's take a look at some of these differences. One is length. Fatty acids can be short or long. Another more important difference is the type of bond between the carbon atoms. Some fatty acids have only single bonds. Others have both single and double bonds. Fatty acids with only single bonds are called saturated and those with one or more double bonds are called unsaturated.

Now, most unsaturated fats are good for you while saturated fats are bad for you in excess. For saturated fats, the story pretty much ends there, but not for unsaturated fats. The double bonds in these molecules have kind of a weird property. They're rigid. So that means that there are two ways to arrange every double bond. The first is like this, where both hydrogens are on the same side and both carbons are on the same side. The second way is like this. Now the hydrogens and carbons are on opposite sides of the double bond. Now, even though both of these molecules are made up of exactly the same building blocks, they are two completely different substances and they behave completely differently inside of us. The configuration on the left is called cis, which you've probably never heard of. The one on the right is called trans and you probably have heard of trans fats before. They don't go rancid, they're more stable during deep frying and they can change the texture of foods in ways that other fats just can't. They're also terrible for your health by far worse than saturated fat, even though technically they're a type of unsaturated fat. Now, I know that seems crazy, but your body doesn't care what a molecule looks like on paper. All that matters is the 3D shape, where the molecule fits, where it doesn't, and what pathways it interferes with.

So how do you know if a food has trans fat in it? Well, the only sure way to know is if you see the words partially hydrogenated in the ingredients list. Don't let nutrition labels or advertising fool you. The FDA allows manufacturers to claim that their products contain, quote, zero grams of trans fat, even if they actually have up to half a gram per serving. But there are no hard and fast rules about how small a serving can be. And that means you'll have to rely on seeing those keywords, partially hydrogenated because that's how trans fats are made by partially hydrogenated unsaturated fats. So let's go back to our olive oil and pancake mix from before. Olive oil is 100 percent fat. Pancake mix is only 11 percent fat, but olive oil is mostly unsaturated fat and it has no trans fat at all. On the other hand, more than half the fat in pancake mix is either saturated or trans fat. And so even though olive oil has 10 times as much fat as pancake mix, it's healthy for you, whereas pancake mix is not. Now, I'm not trying to pick on pancake mix. There are lots of foods with this type of fat profile. The point is this. It's not how much fat you eat, it's what kind of fat. And what makes a particular fat, healthy or unhealthy is its shape.

Theme 1.1

When teacher A introduced the biochemistry of lipids, she designed pre-tutorial learning activities that required students to understand the basic structure and function of lipids

Week 2

Evolution of Eukaryotes

On this page, you will learn about the Evolution of Eukaryotes. Complete the following exercises.

1. Based on the figure provided, answer the questions in Activity 1.
2. Watch the endosymbiosis video and answer the questions in Activity 2.

Activity 1

Edit Reports

Evolution of Eukaryotes 1 / 2

The phylogenetic tree* below shows the major Supergroups in the Eukarya. it represents a phylogenetic hypothesis for the relationships among eukaryotes on Earth today. The eukaryotic groups at the branch tips are related in larger "supergroups" labelled vertically at the far right of the tree. Groups that were formerly classified in the kingdom Protista are highlighted in yellow. Dotted lines indicate evolutionary relationships that are uncertain and proposed clades that are under active debate. (Urry et al., 2018)

**phylogenetic tree: the systematic study of reconstructing the past evolutionary history of extant species*

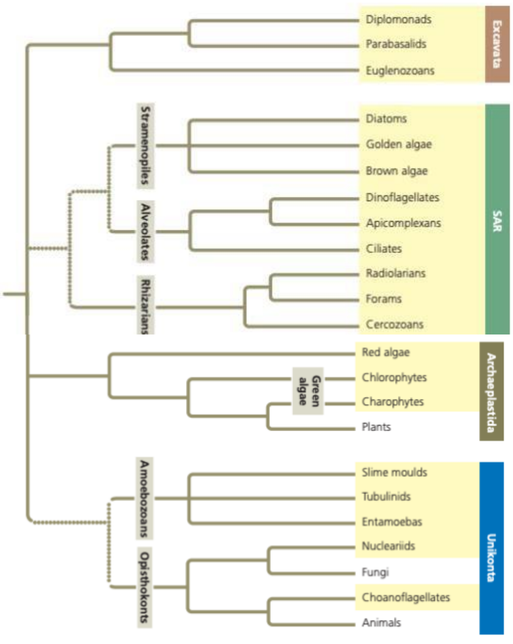


Fig. major supergroups in the Domain Eukarya (Urry et al., 2018)

Question 1: According to the above figure, how many major Supergroups are present in Eukarya?

- ○ 2
- ○ 3
- ○ 4
- ○ 1

Check

Question 2: Which group does each of the following organisms belong to? Drag the words into the correct boxes

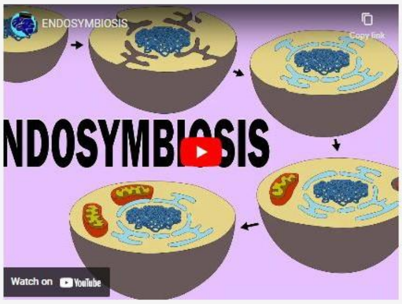
Animals belong to the ______ group
Diatoms belong to the ______ group
Green algae belong to the ______ group
______ belong to the Archaeplastida group
______ belong to the Unikonta group

Unikonta
SAR
Fungi
Archaeplastida
Plants

Check

Video

Serial endosymbiosis hypotheses were proposed to explain how eukaryotes evolved. Do you remember it from *Cell Biology and Genetics* last semester? Watch this video to refresh your memory and answer the questions that followed.



Transcript

Today mitochondria and chloroplasts would not be able to survive outside a cell but according to the endosymbiotic theory they were once independently living cells. The first cells on earth are thought to have appeared around 3.8 billion years ago, 750 million years after the Earth's formation. These cells were prokaryotes, cells lacking organelles or other internal membrane-bound structures.

It wasn't until 2.7 billion years ago that eukaryotes, cells with a nucleus enclosed in membranes appeared in the fossil record. Eukaryotes evolved from prokaryotes. Here is how that is thought to have happened: a prokaryote grew in size and as it did its surface area to volume ratio decreased, this is a problem because it now needs to feed more bulk but it has less surface area to gather nutrients. So to increase the ratio again, the cell developed in folding in its membrane eventually these in folding pinched off from the cell membrane to form an early endomembrane system surrounding the nucleoid. This was the first membrane-bound nucleus and hence this was the first eukaryotic cell. This eukaryotic cell endo phagocytosed and aerobic or oxygen using prokaryotic cell which may have been prey or a parasite genomic sequencing of cells today indicates that this prokaryote was from a group of bacteria called the alpha Proteobacteria. In any case, this cell avoids digestion and becomes an endosymbiotic.

In other words, a cell living within another cell. Funnily enough, this endosymbiont became useful to the eukaryote the aerobic prokaryote was able to use oxygen to make energy a process called respiration, which was nice because the Earth's oxygen concentrations were increasing at this time due to the activity of cyanobacteria. The aerobic prokaryote benefited from its host because the cytoplasm was full of half digested food molecules digesting these molecules with oxygen.

The prokaryote produced so much energy that some of the ATP leaked into the cell's cytoplasm array so as other eukaryotes went extinct. From the rising oxygen levels the Eukarya and the endosymbiont became best pals with the endosymbiont becoming a mitochondrion. At this point, the endosymbiotic became an obligate in those symbion, meaning it cannot survive on its own outside the cell.

Sometime later, the same process occurred with a cyanobacterium which became the chloroplast. This eukarya carry out was the ancestor of plants and algae, we know that chloroplasts evolved later because plant cells have both mitochondria and chloroplasts while animal cells have only mitochondria but what's the proof that endosymbiosis happened. First mitochondria and chloroplasts replicate on their own through something similar to binary fission and cells cannot create new ones, otherwise the genome of these organelles is also remarkably similar to those of prokaryotes mitochondria chloroplasts in bacteria all have a single circular DNA molecule.

In addition porins and cardiolipin are only found in mitochondria chloroplasts and bacteria, so if mitochondria can only come from other mitochondria how do you get your mitochondria in the first place? well your mitochondria come from your mom so next time someone says your genetic info is 50-50 you can tell them that.

Activity 2

Answer the questions below to check your understanding about serial endosymbiosis.

Edit Reports

Serial endosymbiosis 1 / 2

Question 1: Drag the words into the correct boxes to demonstrate your knowledge about Serial endosymbiosis.

In summary, eukaryotes are much more complex than prokaryotes. Eukaryotes:

- have a ______ and ______ organelles
- are much ______ than prokaryotes
- have a more complex life cycles, involving mitosis and meiosis; while prokaryotes usually reproduce by ______.
- have a more complex ______

larger
membrane-bound
binary fission
nucleus
morphology

Check

Question 2: Eukaryotes have membrane-bound organelles. State what different prokaryotes evolved into different organelles (cellular structures). Drag the words into the correct boxes.

- Nucleus and endoplasmic reticulum: ______
- Mitochondria: ______
- Chloroplast: ______

purple bacteria
photosynthetic bacteria
infolding of plasma membrane

Check

Serial endosymbiosis 1 / 2

Reuse I am confused

Theme 1.1

Teacher B unpacked the concept of eukaryotic evolution by providing an evolution tree diagram, followed by a video explaining the endosymbiosis theory on a Canvas page

Activity

Group Discussion

Background: Sympathetic Nervous system

Task:

1. With the aid of flowchart provided, explain the feedback/ responses.
2. Discuss the classwork questions in groups
3. Share your answers with your peers

Resources: Week 7 Coursebook

Activity

Group Discussion

Background: Parasympathetic Nervous system

Task:

1. With the aid of flowchart provided, explain the feedback/ responses.
2. Discuss the classwork questions in groups
3. Share your answers with your peers

Resources: Week 7 Coursebook

Activity

90 seconds brain dump

Background: Review activities for Renal Processes with provided diagrams

Task:

1. Name the 3 key renal processes.
2. Know the pathway of fluid from Bowman's capsule through the kidney tubule all the way to the outside.
3. Explain how the structures of proximal convoluted tubules below are adapted to reabsorption, for examples:
   - High convoluted
   - Thin epithelial tissue Thin
   - Numerous mitochondria
   - Microvilli

Resources: Week 9 Coursebook

Theme 1.2

Students are given the opportunity to explain complicated biological processes to their classmates in the breakout room in Zoom

Activity

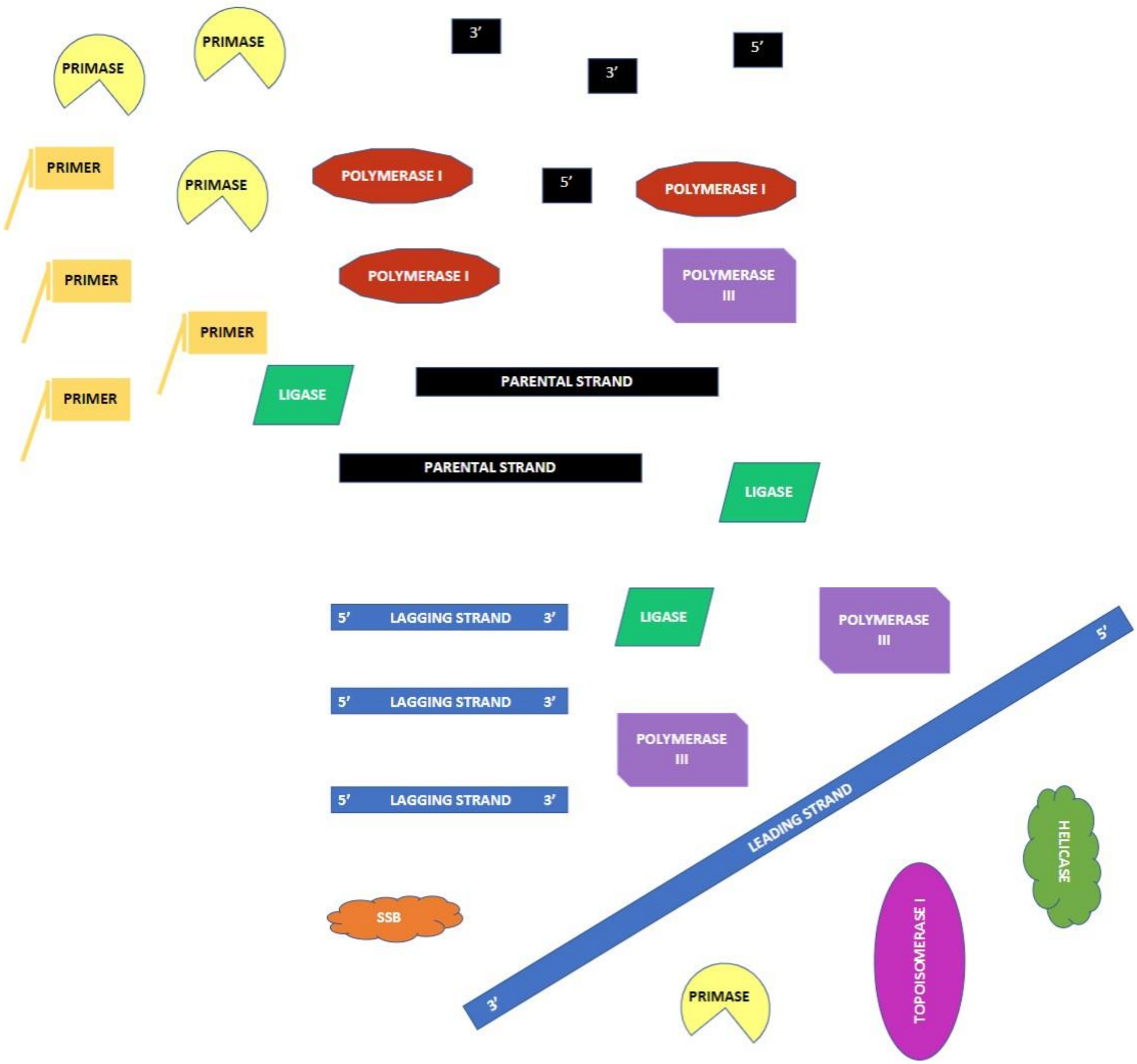
DNA Replication

Background: In pre-tutorial tasks, you have learnt about the discrete enzymes and processes of DNA replication. In this activity, we begin to 'put the pieces of the puzzle together'. We will be using the homemade model kits to conceptualise the replication process.

Task:

1. Have your pre-made model kit available, as well as a $50cm^2$ piece of table or floor available to work on.
2. Wait for instructions from your teacher.

Resources: DNA Replication labels



⮙ Theme 1.2

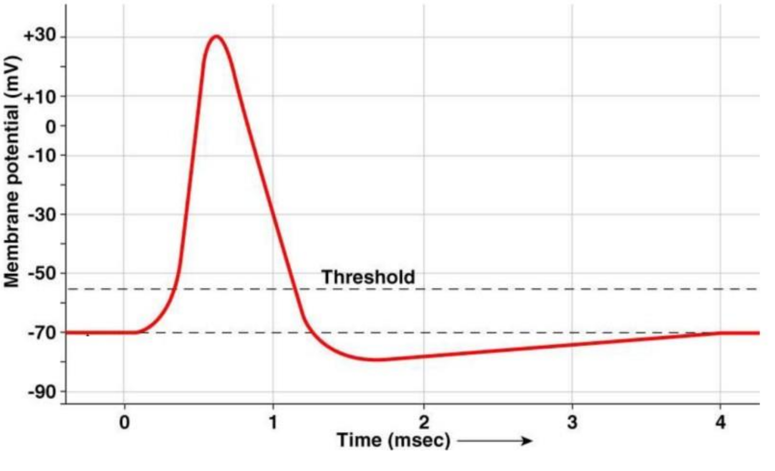
Students are given the opportunity to explain complicated biological processes to their classmates in the breakout room in Zoom

2. Action Potential
   Conduction of nerve impulses requires action potential. To initiate, the membrane is first required to depolarize, i.e. reverse the membrane potential. At the end, there will be a restoring phase that restores the membrane to be polarized, i.e. the resting state. This is known as repolarization.

   Ionic basis of the action potential:
   Depolarization:
   When impulse passes along the axon, mechanical-gated Na+ channels open and Na+ ions enter the cell. If inside of the membrane reach –55 mV (the threshold for eliciting the action potential), then voltage-gated Na+ channels open and more Na+ ions (already 10 times more concentrated outside) enter the axon. Rapid Na+ entry depolarizes the cell, becoming +ve on the inside (+30 mV) and negative outside. This depolarization is known as the action potential.

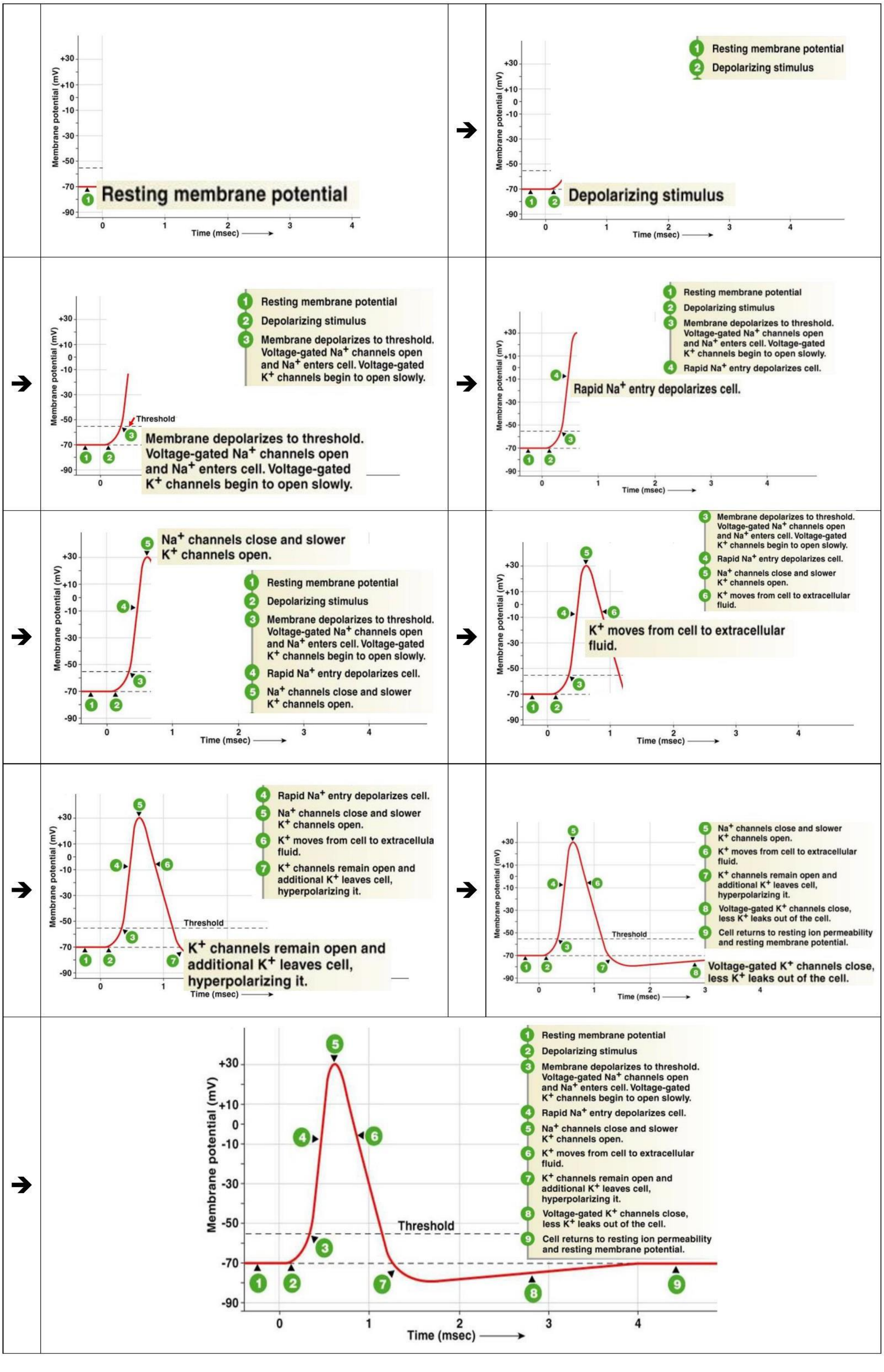
   Repolarization and hyperpolarization:
   At 0.5msec, the Na+ channels close and the voltage-gated K+ channels open causing more K+ ions to leave from the cell to the outside. This marks the beginning of the recovery process in which the inside of the axon regains its negative charge, i.e. re-polarization.
   In fact, K+ channels remain open and additional K+ leaves cell, hyperpolarizing it to –75mV. Finally, voltage-gated K+ channels close, less K+ leaks out of the cell. The sodium/potassium PUMPS take over, and the cell returns to resting membrane potential.

   The graph below shows the changes of membrane potential during nerve impulse generation.



⮙ Theme 1.3

When Teacher B explained the process of nerve impulse transmission, the graphs and textual explanations in the handout were separated



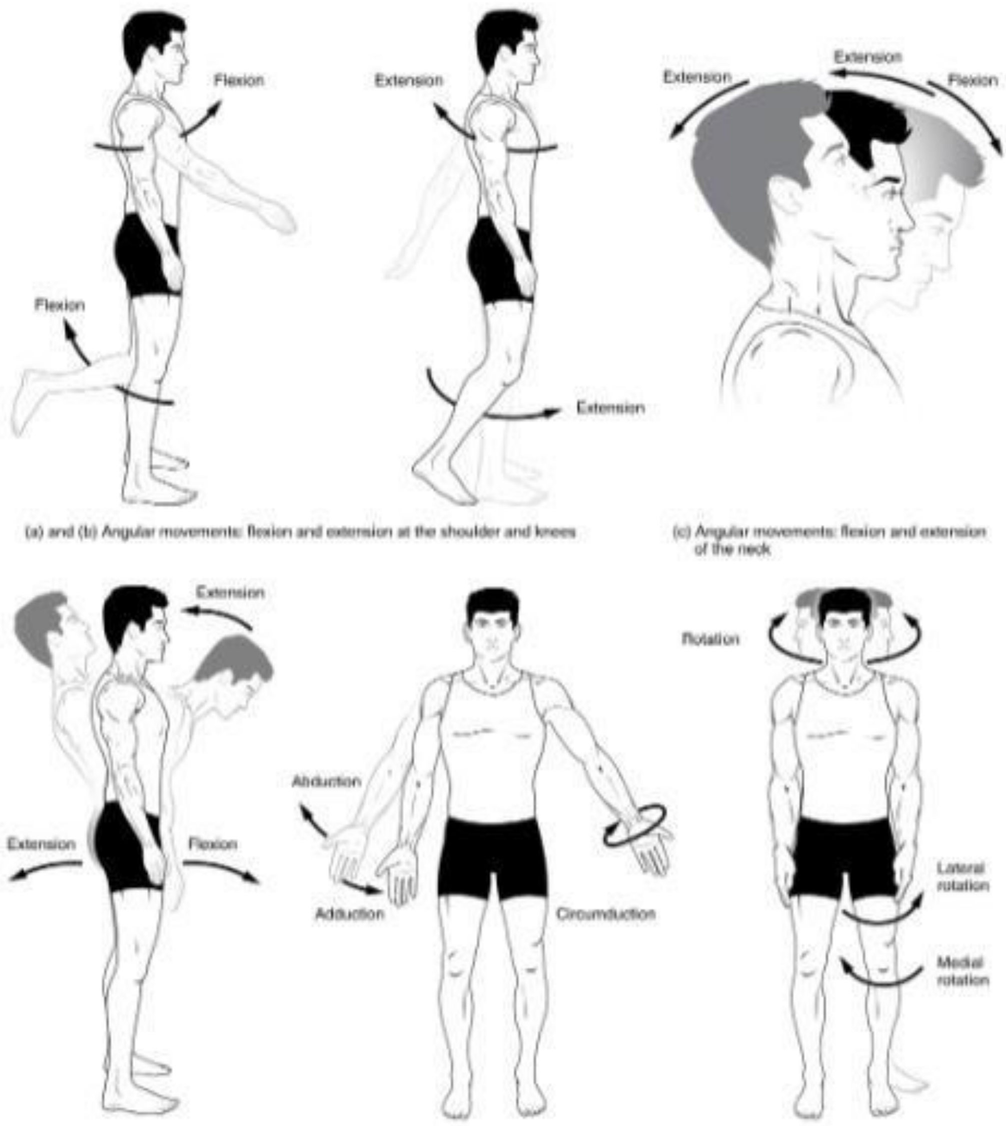
⮙ Theme 1.3

The changes and explanations for the events are now kept together on the graph. This modification effectively eliminated the split of attention.

Activity

In-class exercises	
Background:	Demonstrate 6 types of synovial joints by performing a variety of movements
Task:	1. Everyone stand up to do different movement in different body regions
Resources:	Week 2 Coursebook

Owing to the synovial joints, we can perform different body movements:



(a) and (b) Angular movements: flexion and extension at the shoulder and knees

(c) Angular movements: flexion and extension of the neck

(d) Angular movements: flexion and extension of the vertebral column

(e) Angular movements: abduction, adduction, and circumduction of the upper limb at the shoulder

(f) Rotation of the head, neck, and lower limb

Theme 1.4

This activity is designed to help students understand how different joints enable and disable body movements

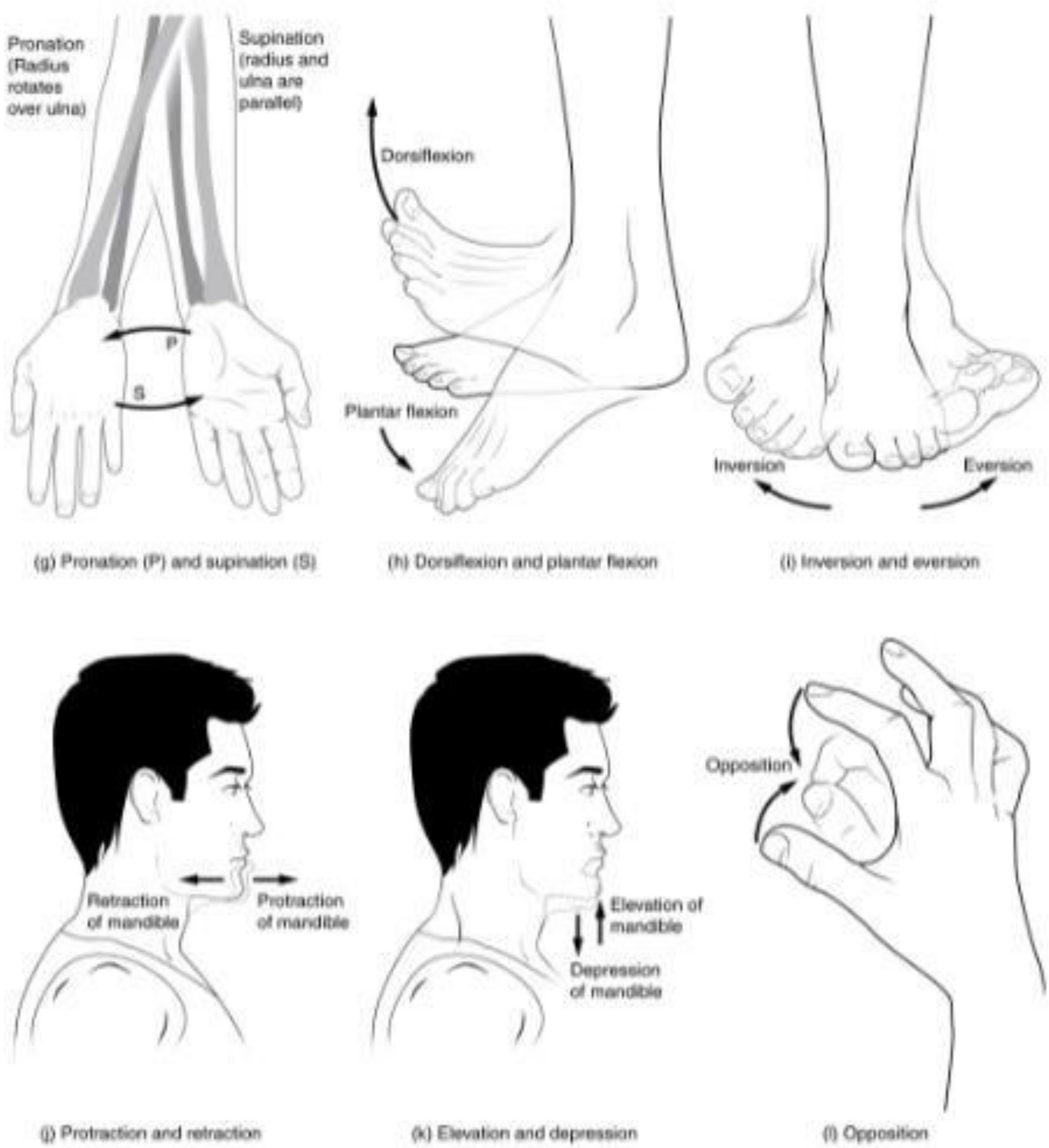
Activity

In-class exercises

Background: Demonstrate 6 types of synovial joints by performing a variety of movements

Task: 1. Everyone stand up to do different movement in different body regions

Resources: Week 2 Coursebook



Theme 1.4

This activity is designed to help students understand how different joints enable and disable body movements

Adaptations for seed dispersal

- Use the sample materials as examples to build a simulated seed dispersed by either wind, water, external animal transport or internal animal transport.
- What are needed to assist this form of transport? Build a seed dispersal model of your choice and compare your seed with other students who have built a seed adapted to other forms of transport.

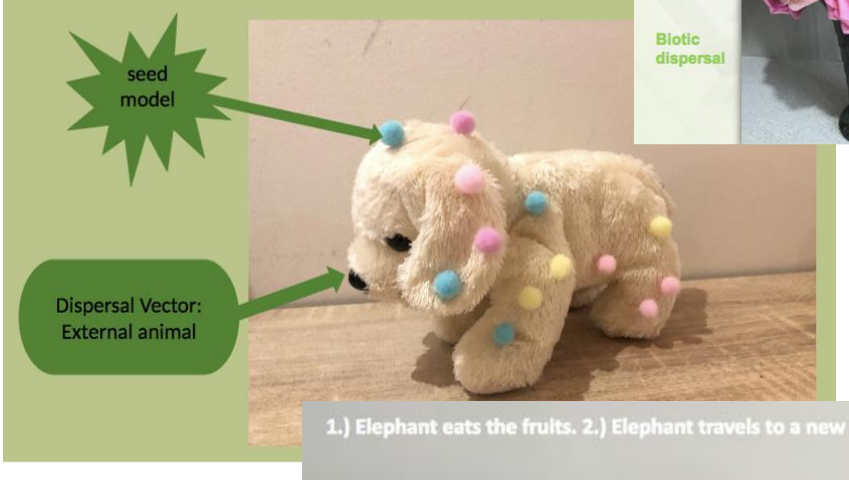
For the seed dispersal model presentation (part of the Practical assessment):

- please submit one PowerPoint file with 2 slides ONLY before Week 6 Tut B.

- Slide 1: Your name, student number, a photo of your seed dispersal model, and dispersal vector (choose only 1 dispersal vector: wind, water, external or internal animals)
- Slide 2: address the following three questions:
  1. adaptation for dispersal
  2. how do these adaptations support dispersal?
  3. examples from nature

- please be ready to present in your Practical 4 class by screen sharing your slides and show the seed dispersal model to the class (by turning on your camera - for online students).

Duration: 1-2 minutes

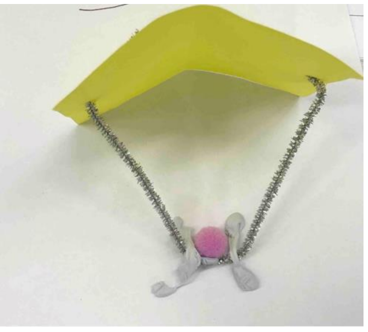


Theme 1.4

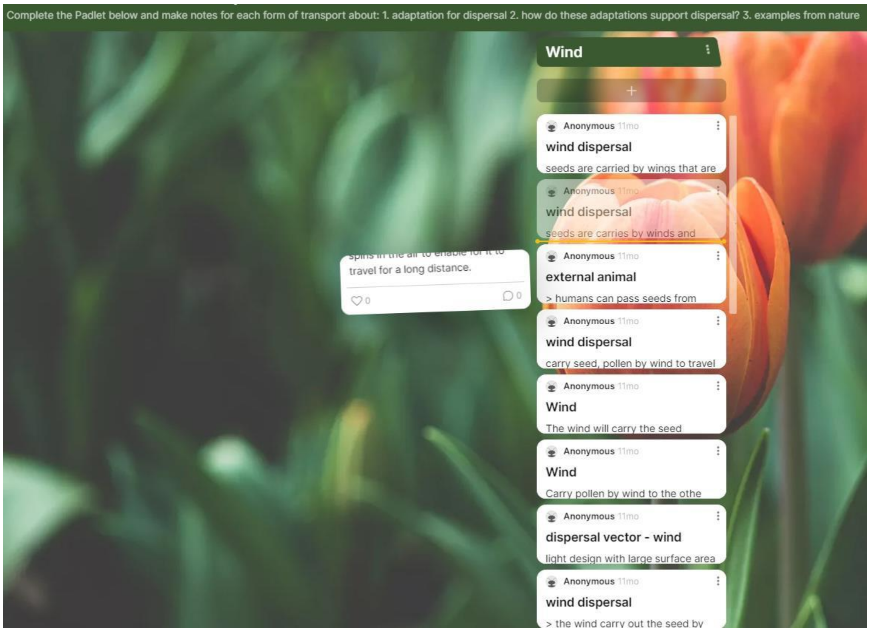
Students to create a simple physical model demonstrating how pollen and seeds are structurally adapted for dispersal.

Adaptations for seed dispersal

- Use the sample materials as examples to build a simulated seed dispersed by either wind, water, external animal transport or internal animal transport.
- What are needed to assist this form of transport? Build a seed dispersal model of your choice and compare your seed with other students who have built a seed adapted to other forms of transport.



Water seed dispersal model



⮙ Theme 1.4

Students to create a simple physical model demonstrating how pollen and seeds are structurally adapted for dispersal

Activity

The three-dimensional structure of proteins is held together by hydrogen bonds, hydrophobic interactions, disulfide linkages, and ionic bonds. These can be disrupted by the environment in which the protein resides. Here, you will be asked to do a home experiment to test if and how these bonds can be disturbed and what the final result will be.

Besides eggs, ask yourself what other foods are high in protein.

Edit

Aim

1. To investigate the effect of temperature on egg proteins.
2. To investigate the effect of different chemicals on egg proteins.

3 / 8

Equipment:

1/3 cup rubbing alcohol (Isopropyl alcohol)

2 eggs (split into three parts each)

1 cup cold water

1 cup boiled water

1 fork

1 pair scissors

1 bowl

6 small glass jars or glasses (about the same size)

Isopropyl Alcohol

(This can be bought from hardware stores as a hard surface cleaner. Get a product with greater than or equal to 70% isopropyl alcohol).

4 / 8

Method:

1. Crack two eggs into a bowl. Separate the yolk from the egg white. (You will only use the white)
2. Divide the egg whites into 6 portions.
3. Put each of the portions into six small glasses.
4. Boil a cup of water.

5 / 8

Method:

5. Set up six small glass containers (environments), each with egg white and.....

   i. nothing else (this is your control)
   ii. 1/3 cup boiling water
   iii. 1/3 cup isopropyl alcohol
   iv. 1/3 cup room temperature water
   v. 1/3 cup **option 1**
   vi. 1/3 cup **option 2**

For option 1 and 2.

You could choose from the following, or come up with something yourself.

(Concentrated bicarb soda in water, mild detergent in water, concentrated salt solution, vinegar)

6 / 8

Method:

7. Photograph the 6 glasses as soon as you've finished preparing them.

8. Observe any immediate changes that occur in terms of egg white colour and consistency.

9. You could gently stir the treatments with a fork, but be sure to rinse your fork between samples.

10. Wait for 30 minutes, then observe and photograph the samples again.

11. Wait for 1 hour, then observe and photograph the samples again.

7 / 8

For the discussion.

1. Post a selfie of yourself with your completed experiments.
2. Write a brief discussion to your experiment. Consider the following key points.
   - What environmental conditions (thermal or chemical) did you treat your egg with?
   - What conditions adversely affected the egg white? Of those conditions, which chemical bonds would be disrupted in the egg? (ionic, hydrogen, hydrocarbon, disulfide)

8 / 8

Theme 1.4

Teacher A gave students a kinaesthetic experience by conducting home

Activity

The three-dimensional structure of proteins is held together by hydrogen bonds, hydrophobic interactions, disulfide linkages, and ionic bonds. These can be disrupted by the environment in which the protein resides. Here, you will be asked to do a home experiment to test if and how these bonds can be disturbed and what the final result will be.

Besides eggs, ask yourself what other foods are high in protein.

Edit

[redacted]

Immediately after solutions have been added:

Control ^ boiling water ^ isopropyl ^ RT water ^ salt water ^ vinegar ^

30 minutes after solution is added:

Control ^ boiling water^ isopropyl ^ RT ^ salt water ^ vinegar ^

60 minutes after solution is added:

There was a chemical change in the environment on 5 of the 6 eggs as there was nothing to change or add to the control of the experiment, the other 5 egg white samples had a chemical change as different solutions and chemicals were added to the samples. Out of the 6 eggs only 1 egg white had a thermal change as it had boiling water added, whereas the other samples were all room temperature.

Out of the 6 samples the **isopropyl alcohol** sample changed the most, causing the egg white to thicken and harden and change colour from transparent to opaque white. The **vinegar** sample also changed colour to opaque white and caused the egg white to move to the middle of the solution. The **room temperature** sample changed the egg whites to a stringy texture and changed the colour to opaque white, whereas the **boiling water** sample had the same effect as the room temperature sample but to a lesser degree. The **saltwater** sample had no change, and the **control** also had no change.

In these conditions it has shown that the disulfide bonds within the egg whites have been disrupted due to the chemical changes in the environment.

Theme 1.4

The teacher compiled a list of questions about the tasks that the students could respond in the discussion forum.

Students also posted their experimental setup with videos and selfies in the discussion forum, providing evidence of

[redacted]

 -after 30mins and 1 hour.  initial time of experiment.

- The thermal condition was constant as room temperature was controlled and constant. No exposure to chemicals present in this experiment. All test subjects were exposed to the same condition.

- **Control**. Egg whites start out clear. They are almost 90% water, but the other 10% is packed with proteins. Egg whites contain more than 50% of the proteins found in the egg.
- **(hot water)**. At the point when eggs are cooked with heat, the egg whites abandon clear to white, and the gel turns out to be more rubbery. As intensity denatured the proteins in the egg white, it broke apart some of the bonds (mostly hydrogen bonds) that were holding the proteins in their unique shape. The proteins unfolded, occupying more room (turning the gel white) and solidifying them set up close to each other.
- **Alcohol**. Alcohol likewise denatures proteins. It does this the same way as heat, by breaking the bonds that hold parts of the protein in a folded shape. Sometimes the alcohol molecules bond directly to some of the parts of the protein, disrupting the normal way the protein would bond to itself. Once in a while the liquor particles bond straightforwardly to a portion of the pieces of the protein, upsetting the ordinary way the protein would cling to itself. (So liquor is known as a "bond disruptor.") The proteins again unfurled, occupying more room and solidifying set up close to each other.
- **Room temperature water**. Sometimes in this experiment, room temperature water has a small denaturing effect on some of the egg white. It acts in the same way, by breaking bonds, but its effect isn't nearly as strong as alcohol or hot water.
- **Vinegar** : the egg white was effected by the acid that caused the salt to form; disruption of hydrogen bonds.
- **bicarbonate soda** : competition for hydrogen bonds and breaks down some of the bonds (precipitation of soluble proteins)

Activity

The following home experiment allows you to extract DNA from fruits, using items and chemicals from around the home. Although the techniques here are crude, they provide a basic framework for how professional scientists extract DNA for their daily research or manufacturing.

Edit

DNA, the genetic basis for life, is in every organism. Under an electron micrograph it looks like a spiral ladder. But what does it look like to the visible eye?

In this experiment, we extract DNA from fruit using household items and chemicals. Later in the semester, we will analyse DNA in the laboratory using gel electrophoresis.

2 / 10

Equipment:

- 1/2 cup fresh fruit
- approx 1/2 cup of chilled isopropyl alcohol
- 1/2 cup hot water
- 1 tsp salt
- 1/2 tsp dishwashing liquid
- resealable zip-lock bag
- scrap cotton fabric (approx 15cm x 15cm)
- narrow glass (a champagne glass works well)
- toothpicks

Fresh Fruit

(It must be a soft fruit, capable of being mashed. Strawberries, kiwi fruit and banana's are a good option but you could try other other fruits if they are available)

Isopropyl Alcohol

(This can be bought from hardware stores as a hard surface cleaner. It is also present in antiseptic cleaners from your grocery store. Get a product with greater than 70% isopropyl alcohol).

4 / 10

Method:

1. Mash the fruit in the resealable bag for about one minute. All the lumps should be gone and the consistency should look like pudding.
2. Dissolve the salt with 1/2 cup hot water.
3. Pour the saltwater mix into the bag.
4. Seal the bag and gently squeeze the fruit / saltwater mixture for approximately 60 seconds.
5. Add the dishwashing soap into the bag and mix very gently. Avoid making foam.

Step 1: mashed banana

5 / 10

Method:

6. Place a small piece of cloth into the top of a glass.
7. Poor the banana slurry into the fabric. A clear liquid will flow through, leaving residual banana lumps behind. Collect approximately 1/3 cup of liquid in the glass.
8. Discard the used fabric.

Step 7: filtering the banana slush

6 / 10

Method:

9. Tilt the glass and **slowly** add the chilled isopropyl alcohol down the side of the cup. Be careful not to pour too fast as you dont want the solutions to mix. Make the layer of alcohol about 2.5 to 5 cm thick.
10. Observe the reaction for 10 minutes. DNA will start forming in the isopropyl layer.
11. At the end of 10 minutes, use a toothpick to lift DNA from the solution.

Step 9: Layering the isoproyl alcohol with the banana flow-through

7 / 10

Results

.........after waiting 10 minutes.

The DNA precipitates in the upper layer of isopropyl alcohol. It can be gently removed with a toothpick.

8 / 10

Theme 1.4

Teacher A gave students a kinaesthetic experience by conducting home experiments

Activity

The following home experiment allows you to extract DNA from fruits, using items and chemicals from around the home. Although the techniques here are crude, they provide a basic framework for how professional scientists extract DNA for their daily research or manufacturing.

Edit

1 / 10

Reuse

Theme 1.4

The teacher compiled a list of questions about the tasks that the students could respond in the discussion forum. Students also posted their experimental setup with videos and selfies in the discussion forum, providing evidence of their first-hand experience for the teacher

[redacted]

Most DNA is located in the nucleus, so when the nucleus of the banana breaks, DNA is released.

The soap helps break down cell films and delivery DNA. The salt unites the DNA, and the chilly liquor helps the DNA encourage and emerge from arrangement so it very well may be collected.

Isopropyl alcohol is used as inexpensive solvent for cosmetics, drugs, shellacs, and gums, as well as for denaturing ethanol. Lab technicians can add ethanol or isopropyl alcohol (rubbing alcohol) so the DNA bunches and structure a noticeable white encourage. It's vital to utilize cold alcohol since it permits a bigger measure of DNA to be extricated. If the alcohol is too warm, it may cause the DNA to denature.

[redacted]

For the discussion.

Post a selfie of yourself with your completed experiments.

Write a brief discussion of your experiment. Consider the following key points.

1. What parts of the cell had to be broken down to release the DNA?

To release the DNA, you must first get past three barriers: the cell wall, the plasma membrane, and the nuclear membrane.

2. What was the purpose of the saltwater and dishwashing detergent?

The salt protects the negative phosphate ends of DNA, allowing them to close and precipitate out of a cold alcohol solution. The detergent breaks down the cell membrane by dissolving the cell's lipids and proteins and destroying the links that hold the cell membrane together.

3. What was the purpose of the isopropyl alcohol?

The DNA clumps and creates a visible white precipitate when lab technicians add isopropyl alcohol (rubbing alcohol). It is critical to use cold alcohol because it allows for more DNA extraction. If the alcohol is excessively hot, the DNA may denature (bold), or break down.

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[redacted]

Home experimentD.pdf

Dna from fruit
Fruit juice had to be mixed with salt water and dish washing soap , which could be the factors that broke down the dna and was found through the rubbing alcohol.

Maybe it helped in popping the cell out from solution. Pulling apart the membrane or helping it dissolve as it could play the role of the lipid layer.
Which gets the dna out to top.

The role of the alcohol was to get the dna to react and form, mend together and then be visible to pick up .

Task 2. Collaborative Activity (Total: 20 minutes)

Compare the nature and functions of the skeletal systems of an earthworm, a grasshopper and a man.

		Earthworm	Grasshopper	Man
1. Skeleton				
Nature	**2. Type**			
	3. Components			
	4. Segmentation?			
	5. Jointed?			
Functions	**6. For protection?**			
	7. To maintain shape?			
	8. For support?			
	9. For movement?			
10. Other functions				

Theme 2.2

Teacher B assigned her students to work in groups of three to compare and contrast the nature and functions of the skeletal systems of an earthworm, a grasshopper, and a man.

Question 3. Reflective Activity (Total: 10 minutes)

Write down three to five pieces of information (knowledge) that you did not know before this Tutorials.

____

____

____

____

____

Theme 2.2

A task at the end of the worksheet required students to reflect on concepts they had not previously mastered and what they had learned from one another through collaborative activities.

Seed plants and **mammals** living in the terrestrial environment are subject to the problem of desiccation. Discuss the adaptations which enable them to over this problem.

Guided questions
What are the two members of the seed plants?

Reading the guided questions and hints, and drafting the response (20 mins)

<u>Seed plants</u>

Guided questions and hints	
Absorption of water	Any adaptive features to facilitate the absorption of water? (Hint: which structure is to absorb water in plants? What special features do they have to absorb more water?)
Maintenance of water	Any adaptations for water conservation? (Hint: cellular structure)
Prevention of water loss	Any structural adaptations to prevent water loss? (Hints: leaf, stem, seed, fruit)
	Regarding the gas exchange surface, are there any adaptations to prevent water loss? (hint: where do plants conduct their gas exchange?)
	In reproduction, how gametes and embryos are prevented from desiccation? (hint: gametes – the pollens, and the embryo is inside the seed)

<u>Mammals</u>

Guided questions and hints	
Absorption of water	Any adaptive features to facilitate the absorption of water? (e.g. any behaviours?, which part of the digestive system facilities the water absorption?)
Maintenance of water	Any adaptations for water conservation? (hint: which organ is to regulate the water content in our body?)
Prevention of water loss	Any structural adaptations to prevent water loss? (hint: our skin?)
	Regarding the gas exchange surface, are there any adaptations to prevent water loss? (hint: where is it? surface or deep down inside our body?)
	In reproduction, how gametes and embryos are prevented from desiccation?

Theme 2.3

Teacher B provided guided questions, diagrams, and hints to help students

Areas	Seed plants	Mammals
Absorption of water		
Maintenance of water		
Prevention of water loss		

Theme 2.3

Teacher B also gave students a proforma to use in recording and reporting the outcome of the discussion

Managing a discussion

FUNCTION	EXAMPLES OF DISCUSSION LANGUAGE
Raise a starting point	An important perspective we should consider first is ... What do people think about ...? What if the result was ...? Has it occurred to you that ...?
Give your opinion	As far as I'm concerned ... I would say that ... It's quite clear that ... I think ...
Agree	I take your point. I don't think anyone would disagree with that. That is logical. I'd go along with you on that.
Disagree	I can't say I share your view. I can't see how that can be. But it could be argued that ...
Manage interruptions (you may also need to do this during your presentation)	Thank you. I was just coming to that. I plan to deal with that later. Can we leave that until discussion time? Thank you, but some other points need to come first.

Theme 2.4

Students are provided with language tips

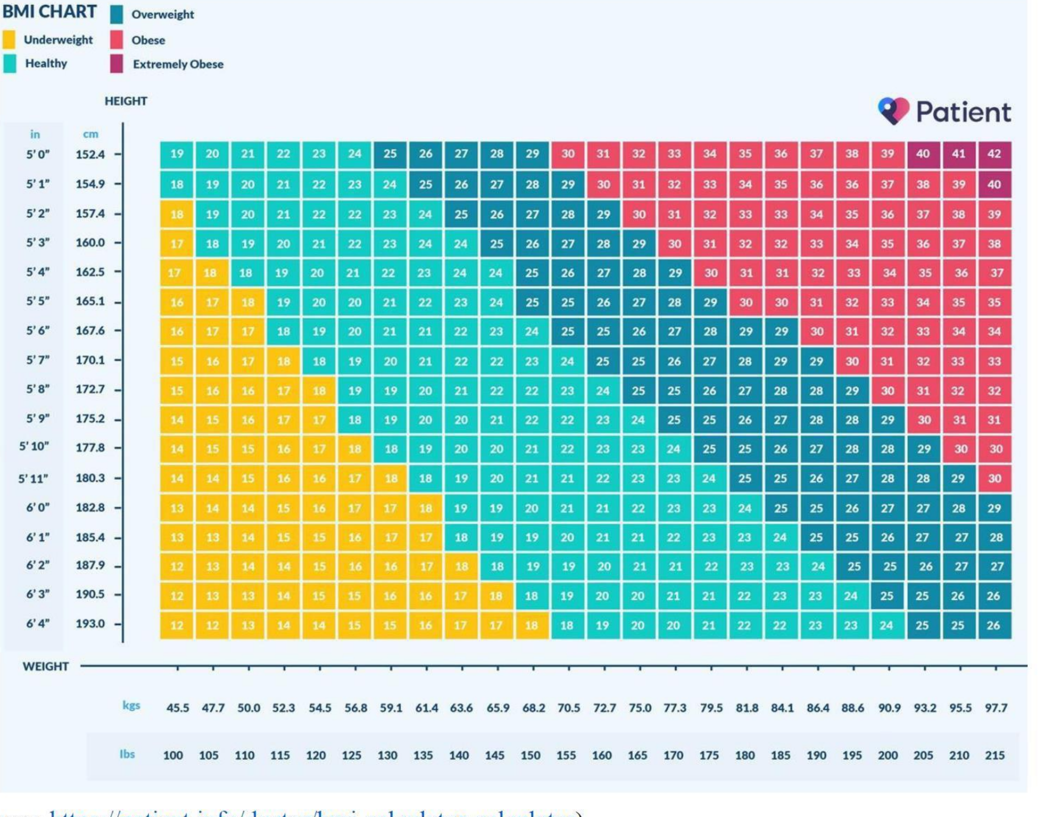
Body Mass Index

Human beings come in all shapes and sizes. Body mass index, or BMI, gives an indication of your body size. BMI is calculated using your weight and height (your weight divided by your height squared).

$$\text{Body Mass Index (BMI)} = \frac{\text{mass}}{(\text{height})^2}$$

1. Calculate the BMI for your family members. Then based on the BMI chart below, state the body condition. (Add more rows, if necessary)

Family member	Mass kg	Height m	Height^2	BMI	Body condition
You					



(Source: https://patient.info/doctor/bmi-calculator-calculator)

Theme 3.1

Teacher B asked students to record their family members' body height and weight data and compute the BMI. Students then analysed the data and used their knowledge to give their family members health advice, including exercise and diet plans.

2. Based on the BMI and body conditions, design diets suitable for your family members.

Theme 3.1

Teacher B asked students to record their family members' body height and weight data and compute the BMI. Students then analysed the data and used their knowledge to give their family members health advice, including exercise and diet plans.

TUTORIAL B: CONNECTION BETWEEN YEAR 2, 3 SUBJECTS (MEDICAL SCIENCE) AT UTS

Year 2

Autumn session

91314 General Microbiology	6cp
91320 Metabolic Biochemistry	6cp
91563 Haematology	6cp
91707 Pharmacology 1	6cp

Spring session

91401 Immunology	6cp
91239 Human Pathophysiology	6cp
91148 Human Genetics and Precision Medicine	6cp
91812 Human Anatomy 2	6cp

Year 3

91709 Pharmacology 2	6cp
91180 Immunology and Human Health	6cp
91194 Evidence Based Practice in Medical Science	6cp
91705 Medical Devices and Diagnostics	6cp

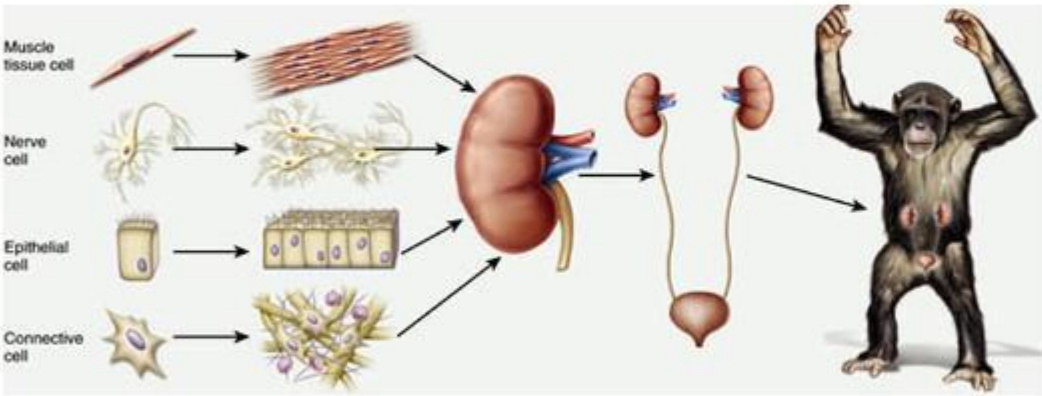
Theme 3.1

Teacher A wanted her students to understand why learning the subject would help them in the future. She listed all the second and third-year subjects from the student's study plan on the screen. She taught her students the definitions of the subject names, such as haematology (the study of blood).

TUTORIAL B: CONNECTION BETWEEN YEAR 2, 3 SUBJECTS (MEDICAL SCIENCE) AT UTS

Levels of organisation: (Fill in the blanks)

__________ __________ __________ __________ __________



Theme 3.1

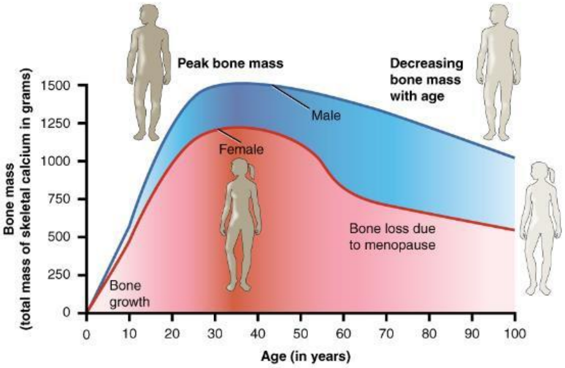
Teacher B has a modified discussion activity in which students are asked to use the levels of body organisation (from cells to tissues, organs, organ systems, and organisms) to understand why they study Cell Biology, Human Anatomy and Physiology, and Biocomplexity).

Discussion: Musculoskeletal System

Background: Now, you have some understanding about the bones and muscles. On this Discussion page, we would like you to post any questions about this week and respond to the questions below.

Task: Respond to one of the questions below:

1. Post any questions, e.g. what is still unclear or confusing, about this week.
2. Osteoporosis is a common disease.



What can you conclude from the information presented in the figure above?

Then, using your own words, summarise in one sentence that explains the cause of osteoporosis.

Everyday Connection:

1. Find information about one disorder within Musculoskeletal System (example: Muscle / Tendon strain, Tension Neck Syndrome and Rotator Cuff Tendonitis). Using your own words, summarise in one sentence that explains the cause in each.
2. Search information about one of the Musculoskeletal System Career Options (examples: Orthopedist, Chiropractor, Physical Therapist). Outline what is the major role of your chosen occupation, and do you want to pursue this career in the future?
3. Post a photo/video of an activity in this week's prac.

Resources: Week 3

Online research

Discussion: Cardiovascular System

Background: Now, you have explored the cardiovascular system. On this Discussion page, we would like you to post any questions about this week and respond to the questions below

Task: **Answer at least *one* question below:**

1. Post any questions, e.g. what is still unclear or confusing, about this week.
2. On-campus lab students can choose to post a photo of heart dissection or ECG activity.
3. Find information about varicose vein and coronary heart diseases. Using your own words, summarise in one sentence that explains the cause of each of the diseases.
   - Your understanding of the varicose vein will be assessed in the in-class quiz
   - The coronary heart disease will be further discussed in Tutorial A.

Everyday Connection

1. According to *Figure 1: the heart of the blue whale* on Week 4: An Overview of Blood, can you identify all the major blood vessels?
2. What do you know about Cardiopulmonary Resuscitation (CPR) technique?
3. Search information about Cardiovascular System Career Options (examples: Cardiovascular Technician and Cardiologists). Outline what their major roles are.
4. Find information about the following heart diseases. Outline one medical treatment for each.
   - Myocardial Infarction
   - Cardiac Tamponade

Resources: Week 4

⮝ Theme 3.1

Since ERT, both teachers started using online discussion forums to establish the relevance of learning to student career goals

Explore

This time, we are using the same simulation game but we are focussing on the axial skeleton: the skull, vertebral column and thoracic cage. Remember to focus on those bones listed above.

Videos

This video provides you with the extra information about the axial skeleton, for example why the vertebral column is hollow, the details of the different processes in a vertebra, etc.

▸ Transcript

Readings

Overview of Skeletal System

Anatomy and Physiology: 7.1 Divisions of the Skeletal System

OpenStax, 2020

Expected time:

- Reading: 10 minutes
- Note-making: 10 minutes

Access the free textbook

Read the texts and Figure 7.2 Axial and Appendicular Skeleton, and make study notes.

Figure 7.2 Axial and Appendicular Skeleton gives you an overview of the axial skeleton. It consists of the skull, vertebral column and the thoracic cage. The appendicular skeleton is made up of all bones of the upper and lower limbs.

Theme 3.2

A feature shared by both teachers' concept pages was the availability of at least two resources for one single concept.

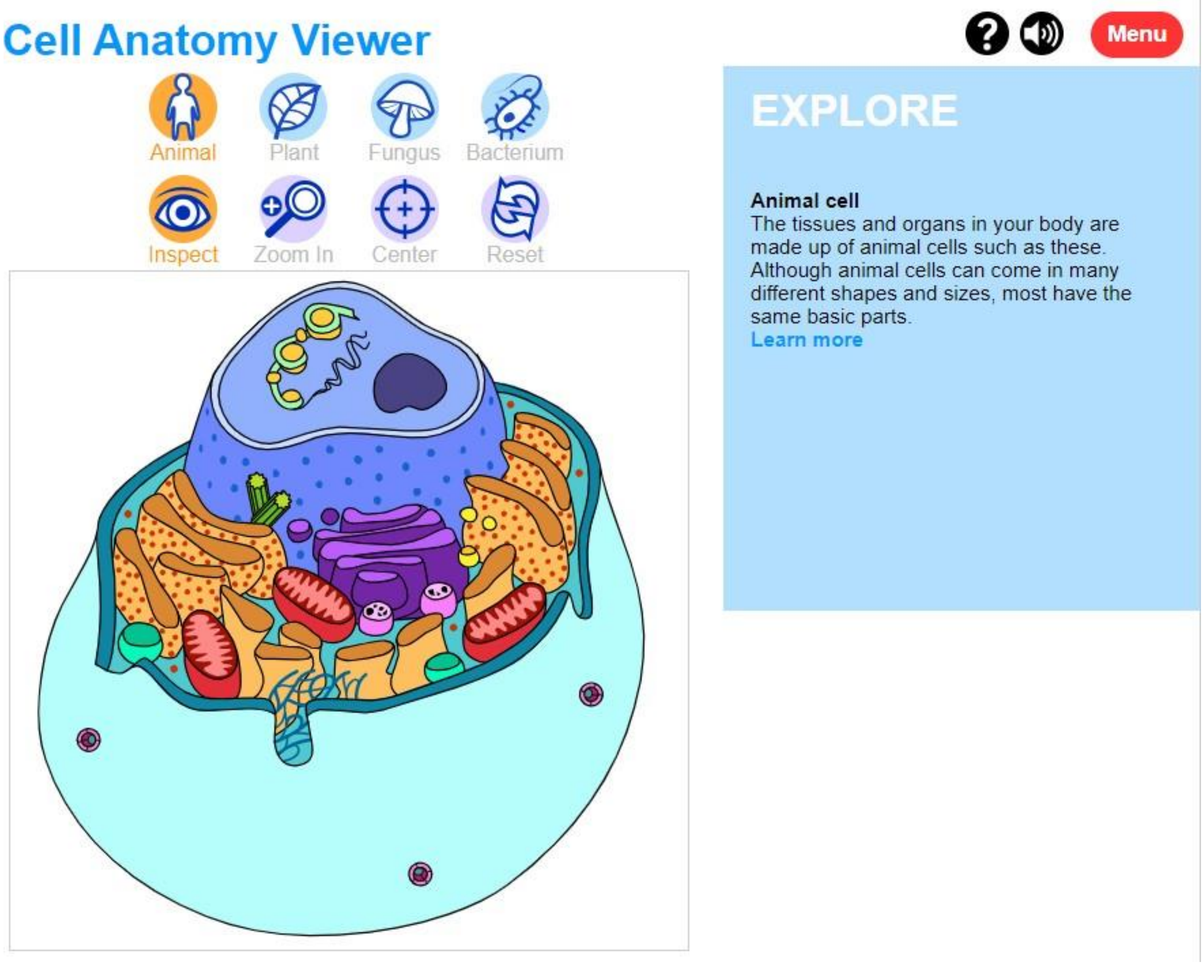
Activity

There are multiple internal structures to eukaryotic cells. In this activity, you will participate in the online game **"Ask a Biologist - Cell Anatomy Viewer"**.

- The game has various levels:- beginner, advanced, and expert. Start with the beginner level and work your way up.
- The game looks at structures and/or organelles of bacteria, animals, plants, and fungi. Investigate the bacteria, plants and animals modules. Ignore fungi, you will learn more about this domain in Biocomplexity.

Use the game as a tool to help identify organelles and learn their key functions. Have your key concept documents open and complete the tables, citing the key structures and functions of organelles.

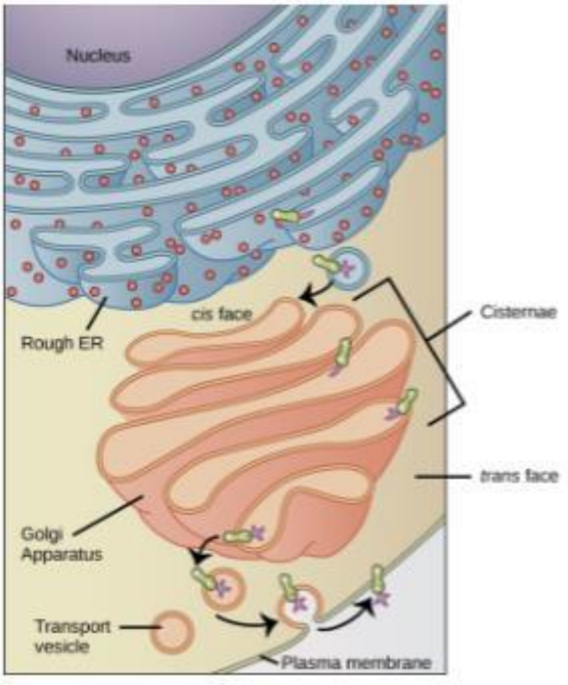
Cell Viewer Game



Theme 3.2

Teacher A's concept page explained all the basic cellular structures and functions. Teacher A and students co-constructed their understanding of more advanced concepts, such as the endomembrane system, during the tutorials.

Exercise 2: The Endomembrane System



The endomembrane system is composed of 5 main components:-

I. Rough endoplasmic reticulum (RER)
II. Smooth endoplasmic reticulum (SER)
III. Golgi apparatus
IV. Vesicles and vacuoles
V. Lysosomes

A. Use the following table to compare the RER and SER.

	Rough Endoplasmic Reticulum (RER)	Smooth Endoplasmic Reticulum (SER)
Structure		
Functions		
Abundance		

B. Proteins within the golgi apparatus are subject to three main actions: modifying, packaging and processing. What is meant by these terms?

Modifying:

Processing:

Packaging:

Theme 3.2

Teacher A's concept page explained all the basic cellular structures and functions. Teacher A and students co-constructed their understanding of more advanced concepts, such as the endomembrane system, during the tutorials.

Activity 2

Key issue: as organisms get bigger, more complexity is required to transfer gases and nutrients. Animals have solved this problem by developing five key transitions into basic body plans over the course of evolution. They are:

1. Symmetry
2. Germ layers
3. Body cavities
4. Development
5. Segmentation

Animals may:

- lack symmetry
- have radial symmetry
- have bilateral symmetry

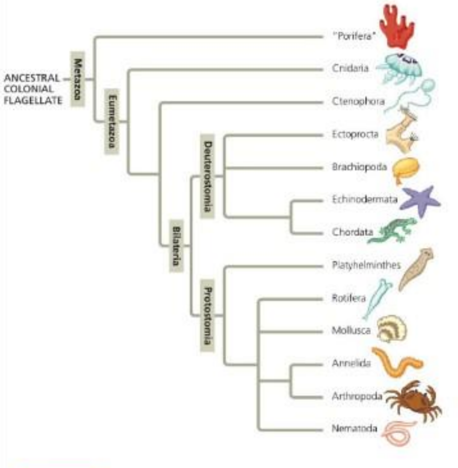
Complete the activity below to learn about it.

Edit | Reports

Five key transitions in animal evolution 1 / 2

Based on the symmetry (if any) of the organisms shown in the following evolution tree, drag and drop the correct words to the boxes.

Drag and drop the correct symmetry types to the corresponding phylum boxes.



radial symmetry

lack of symmetry

bilateral symmetry

Check

From the above diagram, what can you conclude about the symmetry in 'primitive' and 'advanced' animals?

- Primitive animals have no symmetry or radial symmetry whereas advanced animals are usually bilateral.
- Primitive animals have bilateral symmetry whereas advanced animals have no symmetry or radial symmetry.

Check

The significance of different levels of symmetry and the other four transitions - germ layers, body cavities, development and segmentation will further be explored and discussed in Tutorial A.

Five key transitions in animal evolution 1 / 2

Reuse | I am confused

Theme 3.2

Teacher B's concept pages was the five key transitions in animal evolution. The concept pages began by establishing activities for students to explore the meanings of symmetry, germ layers, body cavities, body development, and segmentation. The students then worked together in the tutorial to figure out the details of each change by looking at examples of animals from various phyla.

Week 1: Quiz - Prokaryotes
Due: 10 Mar at 23:59 - SCBG001

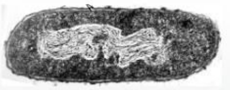
Week 1: Quiz - Prokaryotes results for Lina Almuntak

Score for this attempt: **11** out of 15
Submitted 7 Mar at 20:56
This attempt took 14 minutes.

Question 1 2 / 2 pts

Which of the following cells are Prokaryote?

Correct! bacteria



Correct! These cells lack a defined nucleus and membrane-bound organelles.

Animal

plant

fungus

Additional comments:

Question 2 6 / 7 pts

Match the prokaryotic structure to its function?

Correct!	Fimbriae	Hairlike appendages for attac
Correct!	Capsule	A slimy, sticky layer for attac
Correct!	Cell Wall	Maintains cell shape
Correct!	Cytoplasm	A jelly like substance where I
Correct!	Flagella	For locomotion
Correct!	Plasmid DNA	Small rings or DNA, usually c
You Answered	Pilus	Hairlike appendages for attac

For DNA transfer between two cells

Other Incorrect Match Options:
- Cell membrane
- Endospores
- Circular DNA
- Ribosomes

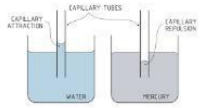
If you struggled with this question, try reinforcing your knowledge of prokaryotic cells by playing this online game.
https://askabiologist.asu.edu/cell-viewer-game/play.html

Additional comments:

Theme 3.3

Since the Canvas Quiz allowed teachers to provide feedback on the question and option levels in text or video, both teachers have begun creating tailor-made feedback for each question

Question 3 2 / 4 pts



Referring the the above diagram:-

(a) Water has a concave meniscus because the molecules have high [Select] to the surface of the capillary tube.

(b) Mercury has a convex meniscus because the molecules have relatively low [Select] to the surface of the capillary tube.

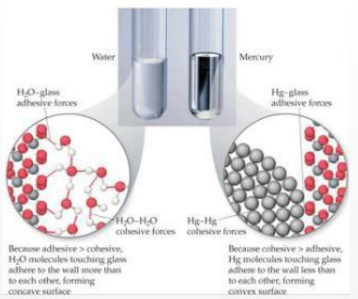
Answer 1:

Correct! adhesion

Answer 2:

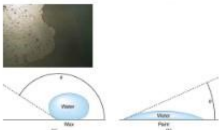
You Answered cohesion

Correct answer adhesion



Additional comments:

Question 4 1.5 / 3 pts



The above image refers to how water beads on a recently waxed car, as opposed to an unwaxed paint surface. Answer the following questions:-

Water forms beads on a waxed surface because hydrogen bonds holding the water together, otherwise known as cohesion , are stronger than the hydrogen bonds between the water molecules and the wax surface surface tension . This is what causes it to 'bead'.

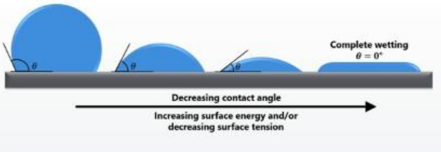
Answer 1:

Correct! cohesion

Answer 2:

You Answered surface tension

Correct answer adhesion



Additional comments:

Theme 3.3

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Question 5 3 / 4 pts

A disaccharide contains two monosaccharides joined together by a glycosidic bond . This is a covalent bond formed by a dehydration reaction

One common examples of a disaccharide is glucose .

Answer 1:

Correct! two

Answer 2:

Correct! glycosidic bond

Answer 3:

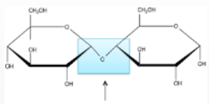
Correct! dehydration

Answer 4:

Correct answer sucrose

You Answered glucose

A disaccharide contains two monosaccharides (di = two). Glycosidic bonds are formed in carbohydrates.



Glycosidic Bond

Additional comments:

Question 6 1 / 1 pts

$CH_3COOH + H_2O \rightleftharpoons CH_3COO^- + H^+$

What type of dissociation reaction is this?

- Weak base
- Strong base
- Strong acid
- Correct! Weak acid

It is an acid reaction because hydrogen ions have been generated. It is a weak reaction because arrows go in two directions, symbolising that the reaction can proceed in both directions.

Additional comments:

Question 7 2 / 2 pts

Both carbohydrates and lipids consist of three elements: carbon, hydrogen and oxygen. However the species differ in their ratios of H:O.

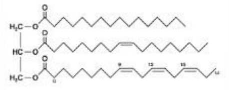
- In carbohydrates, the ratio of H:O is always 2 : 1 .
- In lipids, the ratio of H:O is always greater than than 2:1.

Answer 1:

Correct! 2 : 1

Answer 2:

Correct! greater than

 The above triglyceride is a lipid with the molecular formula of $C_{55}H_{98}O_6$. The ratio of H:O in lipids will always be greater than 2:1. Here it is 98:6.	 The above molecule is glucose with the molecular formula of $C_6H_{12}O_6$. The ratio of H:O in carbohydrates is 2:1. For glucose, we're seeing that it is 12:6 = 2:1.

Additional comments:

Theme 3.3

Since the Canvas Quiz allowed teachers to provide feedback on the question and option levels in text or video, both teachers have begun creating tailor-made feedback for each question

Subject name:	
1a. Generally, how well am I doing in this subject?	1b. On what am I basing this self-evaluation? (my marks? Feedback from teachers? Self-monitoring?)
2a. In this subject, I am best at: What makes me better at these aspects?	2b. On what am I basing this self-evaluation?

3a. To do better in this unit, I need to improve: What prevents me from doing as well at present?	3b. How will I bring about this improvement? My timeline for this improvement is:
4a. What I have learn, or improved from this subject?	4b. How do I know this? How do I measure or monitor what I have learnt? (How long it takes? My level of confidence? My understanding? My level of enjoyment?)

Theme 3.4

Reflective tasks set by Teacher A.

Confidence Checklist

Check if you can answer the following questions.

- The location of the heart (1)
- Label the 3 tissue layers of the heart wall. (3)

External and Internal Anatomy:

- Identify all different blood vessels (both external anatomy and internal anatomy). (6)
- Draw the blood flow through the blood vessels and heart chambers. Be able to tell which one deoxygenated blood is and which one oxygenated blood is. (3)
- Label all internal structures in a heart. (14)
- State the functional role of septum in the heart. (1)

Valve:

- State the function of a valve and thus its significance. (2)
- Identify all the valves. (4)

Ventricles:

- What is the significance of left ventricle wall being extremely muscular? (2)

Theme 3.4

The checklist is a slightly modified version of the lesson objectives. The number in brackets at the end of each objective denotes the level of response required. For example, "the significance of coronary circulation? (3)" indicates that students need to have three valid points about the significance of coronary circulation. Students went through a mental practice to see if they could provide three points about this objective.