

Socially constructing emotion in STEMM university learning and teaching: Implications for emotion- informed curricula and engagement

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Abstract

Even in Science-based STEMM disciplines, considered objective and rational, emotion is integral to learning and teaching. Although emotions are individually felt, they are socially constructed between people. This is particularly relevant in collaborative learning. Despite growing attention, emotion-focused research often lacks strong theoretical framing that foregrounds how emotion functions in university contexts. Taking a social constructionist perspective, this thesis investigates emotional interactions, constructions and meaning making amongst student peers and their teachers, and educational implications. It offers a timely and nuanced way to critically consider the complex and contradictory roles of emotion in education, as universities endeavour to address wellbeing concerns, whilst creating challenging and meaningful learning opportunities.

Applying a social constructionist and pragmatic research orientation, qualitative data was collected from seven departmental case studies in a UK STEMM-focused university, from 280 students via in-situ questionnaires and 23 teachers via focus group and follow-up interviews. Data was rigorously analysed to identify themes that capture key connections between participants' emotional experiences.

The 'Knowing' theme revealed that highly variable emotions were socially constructed as individuals interacted to tackle complex and uncertain knowledge and faced challenges to epistemic goals. The 'Evaluating' theme captured contrasting emotions being constructed as learners and teachers evaluated their achievement of multiple and conflicting educational goals, using social comparison, and felt and inferred emotion as evidence. The 'Empathising' theme evidenced how students and teachers developed awareness of each other's emotions and responded to contextually relevant emotion information to understand each other's goals and regulate each other's emotion.

A model is elaborated to illustrate how socialising agents learn to navigate interacting cognitive and emotional challenges in demanding STEMM academic contexts, and how social construction of emotion contributes. This thesis makes theoretically and empirically underpinned recommendations for developing emotion-informed curricula. The researcher's educational developer positioning enabled an educational development intervention approach.

Statement of Originality

I, Kathryn Ippolito, confirm that the work presented in this thesis is my own. Where the work of others has been used, it has been appropriately acknowledged and cited within the text.

Ideas and direct quotes from published articles based on work written up in this thesis (Ippolito and Kingsbury, 2024) have been cited where appropriate.

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Abbreviations

CVT	Control Value Theory of Achievement Emotion
ER	Emotion Regulation
HE	Higher Education
MEQ	Module Evaluation Questionnaire
MHWP	Mental Health and Well-being
NHS	National Health Service
SOLE	Student Online Evaluation
STEMM	Science, Technology, Engineering, Maths and Medicine
CH	Chemistry
EEE	Electrical and Electronic Engineering
LS	Life Sciences
MD	Medicine
ME	Mechanical Engineering
PH	Physics
TBL	Team-based Learning
UG	Undergraduate
UK	United Kingdom

1. Introduction

The aim of this thesis is to explore the emotional experiences of STEMM university undergraduates (UGs) and teachers and, specifically, the ways that they influence each other's emotions in pursuit of their educational goals. This connection is important because emotions have many implications for the symbiotic processes of university learning and teaching but are only ever considered in terms of their influence on learning and, to a lesser extent, to teaching. This leads to an artificial separation that I argue is unhelpful for all stakeholders. Using a social constructionist-informed and case study-based research approach, emotional interactions in STEMM academic contexts are explored, and pedagogic implications and possibilities for better developing this valuable emotional connection are presented.

1.1 Focus and Rationale

1.1.1 Recognising the value of emotion in STEMM university learning and teaching

The influence of emotion on university student experiences is gaining increasing attention. This includes consideration of the relationship between learner emotion and approaches to learning and academic progress (Postareff et al., 2016), motivation and performance (Pekrun et al., 2011) and wellbeing (Cavanagh, 2023). This is largely driven by psychologists' desire to better understand complex interplay between the inherent challenges of learning, motivation, achievement and wellbeing. The contribution of advances in neuroscience, providing compelling evidence of connections between emotion and learning processes (Immordino-Yang, 2016, Mareshal et al., 2014) are also having a significant impact. There is a smaller, yet growing, body of literature on the emotional experiences of university teachers (Postareff and Lindblom-Ylänne, 2015, Robertson, 2018, Mendzheritskaya and Hansen, 2019). Studies to date demonstrate that students and teachers experience a varied and contrasting range of so-called positive and negative emotions whilst learning (Pekrun and Perry, 2014) and teaching (Postareff and Lindblom-Ylänne, 2011), both of which are important for personal development and psychological wellbeing (Huppert, 2009). The active and collaborative learning approaches, as opposed to didactic methods, that increasingly characterise higher education (HE) curricula and will be the focus of this study, require us to understand the challenges and affordances of emotional interaction in university classrooms (Charalambous et al., 2020).

This study focuses specifically on STEMM HE. STEM refers to a group of subjects that fall within the disciplines of Science, Technology, Engineering and Maths. I have included Medicine along with this, as it is a major faculty within the university at which the study is situated, that contributes to how the university defines itself, and to the university culture, both of which influence emotional experiences. It is also significant that all disciplines grouped under STEMM have curricula that are significantly influenced by scientific, logical ways of thinking and positivist, objective methods that lead to assumptions that these disciplines are unemotional (Kandiko Howson and Kingsbury, 2024). Despite persuasive neuroscientific evidence (Immordino-Yang and Damasio, 2007) that emotion underlies the cognitive processes central to STEMM learning and practice, such as problem-solving and decision-making, persisting beliefs and stereotypes means STEMM disciplines maintain an air of emotional neutrality. This prevents acceptance of the centrality of emotion in STEMM education (Lönngren et al., 2023, Sinatra et al., 2014). In recent years, however, there has been recognition that the complex, collaborative and uncertain nature of problem-solving and decision-making within STEMM-focussed professions requires the development of emotional competence, that could usefully be supported through STEMM HE curricula (General Medical Council, 2020, Strobel et al., 2013).

1.1.2 Developing an emotion-informed understanding of wellbeing in learning

Within contemporary HE more broadly, there is strong impetus to make support for university student and staff mental health and wellbeing (MHWB) a strategic priority, taking a whole university approach (Universities UK, 2017, Imperial, 2023). This involves considering student and staff's emotional experiences in a holistic and connected way. The recent Stepchange Mentally Healthy Universities (Universities UK, 2023) initiative highlights 'Learn' as one of four domains of focus. It begins to acknowledge the complexity of university learning experiences, the discomfort of challenge, the contradictory impact of curricula on participants and the longer-term potential for transformation:

“Universities transform lives through learning. Higher learning involves challenge and new ways of thinking: it can have a positive impact on a person's mental health and wellbeing over a lifetime. However, the way learning is designed, structured and provided may produce a positive or negative experience” (p14).

This seems to imply that better learning design, structure and provision can fix the problem. But is it that simple? The StepChange initiative requires universities to consider what are the positive and negative impacts on MHWB that university curricula produce and how can

we better promote and support MHWB through learning and teaching? Having critically engaged with related literature and in discussions for six years and, given my role as an experienced educational developer and university teacher, I argue that there are important, yet underconsidered, questions that are essential to more fully understanding the links between university learning and teaching and MHWB. These questions involve using an emotion-informed lens to interrogate educational experiences and include: What emotions are actually being experienced in university learning settings, and why? Which of these emotions are important for learning, and how?

The importance of positive peer connection and student-teacher interaction for promoting MHWB is well-recognised (Upsher et al., 2022, Hagenauer and Volet, 2014). However, there is little systematic thinking about how this occurs, nor, specifically, how student peers and teachers influence each other's emotions and implications of this for learning, teaching and wellbeing. This leads to a further question: What are the emotional connections between learners and teachers and how do these influence learning, teaching and wellbeing?

University curricula offer many opportunities for experiencing the range of positive emotions, and learning to manage negative emotions that are important for developing psychological resilience (Huppert, 2009). Learning is an inherently uncomfortable and disorienting process as we confront things that we do not already know and cannot already do.

“This is especially true of the transformative learning expected of higher education (Mezirow, 2009). If learners never feel the discomfort of uncertainty or satisfaction of achievement, how can they be motivated to change themselves and face related challenges in a more developed way in future?” (Ippolito and Kingsbury, 2024 ,p1-2).

In parallel, university teachers experience the discomfort in tolerating and supporting learners' difficult emotions and experience their own, including as they take risks with unfamiliar pedagogical approaches in uncertain learning contexts (Lahtinen, 2008). I argue that better understanding this inevitable cycle of sense of discomfort and of achievement, of emotional experiences with negative and positive valence, must be at the heart of understanding wellbeing in learning and teaching.

1.1.3 Adopting a social constructionist, pragmatic orientation

There are a number of contrasting perspectives on what emotion is and how it occurs (Izard, 2007). These range from discrete, observable emotions being considered universal across

all humans and hard-wired in our brain from birth (Evans, 2003), to emotions being socially constructed between people through interaction and language in sociocultural contexts (Gendron et al., 2014). This study takes the latter perspective, and this will be carefully justified and elaborated in the Literature Review and Theoretical Framework Chapters. To complement this theoretical position, the study adopts a social constructionist approach to conducting the empirical research. This is based on the premise that the ways we perceive and understand the world around us, and people and objects in it, is based on how it is constructed through language (Burr and Dick, 2017). This social constructionist framing and approach ensures that my research participants' ways of making meaning about emotion experienced individually and together, through their learning and teaching-related interactions, will be emphasised. This is complemented by a pragmatic research approach (Savin-Baden and Howell Major, 2013) that will guide the collection and analysis of data, such that it can be used to identify practical implications for curriculum development that take into account the need to balance individuals' academic and emotional development and wellbeing. An educational development approach, afforded by the researcher's positioning as an educational developer, further strengthens the research because the study also functions as an educational development intervention, contributing to the educational understanding and practice of research participants, through the research process itself.

1.2 Research context

The research study took place in a UK, research-intensive, STEMM-focussed university. This is a timely study. As part of Imperial's university-wide curriculum change process (Kandiko Howson and Kingsbury, 2021) some existing wellbeing-related issues, such as pressure from exams, and peer support and culture in relation to academic success (Mentality, 2015) were responded to by reducing content, diversifying away from exam-heavy assessment strategies and better connecting learners through more inclusive, collaborative learning. As the university considers the longer-term impact of these curriculum changes on student experience and embarks on Education Strategy Refresh work, I suggest that educational decision-making should be informed by greater understanding of what emotions are being experienced in our STEMM learning settings, why and what this means for learning and development. In parallel, the university has been developing a new Mental Health and Wellbeing Strategy (Imperial, 2023) that sets out strategic goals aimed at preventative and compassionate measures for building a supportive community and promoting a safe environment that promotes mental wellness. This is seeking to ask fundamental questions such as how Imperial can balance notions of 'pursuit

of excellence' with 'feeling safe'.

1.2.1 My role and perspective within STEMM higher education

Having worked as a university teacher for the last 23 years, with many of those also spent supporting the development of other teachers, I found myself increasingly interested in the role of emotion in learning and teaching processes. In particular, I felt curious about the varied and contrasting emotional experiences that individuals seem to experience, even in the same educational context, and the various ways that learners and teachers appear to influence each other emotionally. I felt if our understanding was more evidence-based and nuanced, teachers and learners could make more informed use of emotion in learning and teaching. As I immersed myself in reading and thinking, I realised what a complex phenomenon emotion is, with many facets and interpretations. I believe that part of the value of this PhD, and its outputs, lies in identifying which of these perspectives, concepts and methodologies are most useful and persuasive for understanding and improving HE experiences and practices, particularly in STEMM disciplines.

In parallel to this PhD, in 2018, I became involved in work, at Imperial and nationally, to better understand and address the apparent increase in student MHWB issues. For five years, I had been working with the Head of Student Counselling and Mental Health Advice Service to develop and deliver training for personal tutors, including in their role supporting tutee wellbeing (Hughes et al., 2017). As some voices within the university sector began to advocate for 'embedding mental wellbeing in the curriculum' (Houghton and Anderson, 2017, Hughes et al., 2022), I began critically considering this prospect and, more specifically, what we could expect of teaching staff, especially in a research-intensive, STEMM context, such as Imperial. What did they think about their role in supporting learner wellbeing through their curricula? What were they already doing in this area? In 2019, I ran an Advance HE project investigating academic and teaching staff perspectives on embedding wellbeing in the curriculum which served as a scoping exercise for this PhD. I am now a member of the Expert Advisory Group for Imperial's MHWB Strategy, advising specifically on the impact of learning, teaching and assessment on mental wellbeing. I want us to critically interrogate educational experiences and decide, in an informed way, which are important for learning and development, and which cause unhelpful emotions, that may negatively impact wellbeing.

In January 2021, I began teaching UGs from across Imperial on the new iExplore module 'Science of Learning'. To date, I have taught a total of 287 students from Faculties of Medicine, Natural Sciences and Engineering in groups of approximately 40, over seven

term-long iterations. This elective module involves students critically evaluating their learning experiences through lenses of neuroscientific, psychological and socio-educational concepts. As the 'science of emotion' spans all three of these fields, I have been able to integrate ideas, data collection and analysis into teaching this module. Students have responded to this 'science of emotion' strand very positively and I have learnt a great deal from them. This has not only given me invaluable critical insight into possibilities for embedding approaches that support emotional understanding into the curriculum, but also confidence in their effectiveness, based on tangible evidence of engagement and impact.

1.3 Aims and research questions

The aim of this empirical study is to gain insight into the emotional experiences of learners and teachers in STEMM university classrooms and the ways they make meaning of these. Furthermore, it seeks to understand how student peers and teachers reciprocally influence each other's emotions and how this impacts on their learning and teaching experiences. Finally, I aim to make recommendations for how enhanced emotional awareness and understanding can be used to improve STEMM curricula and pedagogic engagement.

These aims are translated into the following research questions:

RQ1. What emotional experiences do students and teachers in STEMM university learning and teaching settings socially construct and what attributions do they make for these?

RQ2. What are the reciprocal emotional interactions between student peers and teachers and what factors influence this process?

RQ3. What are the implications, and how can understanding of emotional interaction in STEMM education contexts inform educational design and pedagogy that supports academic development and wellbeing?

1.4 Thesis structure

The thesis is structured to develop and present a logical narrative regarding the ways in which emotion in STEMM university learning and teaching is socially constructed and implications for emotion-informed curricula and engagement. This is elaborated over the following ten chapters:

Chapter 1: Thesis Introduction that sets out the rationale for the research, the factors that influence the study's focus and approach, and the aims and research questions.

Chapter 2: Literature Review that examines what is known about emotion and its role in university learning and teaching, specifically in collaborative, STEMM education.

Chapter 3: Theoretical Framework that draws together selected emotion theories to create a lens through which to understand and examine the social construction of emotion in university learning and teaching.

Chapter 4: Methodology that sets out the methodological choices and gives details about the data collection methods and data analysis approaches used.

Chapter 5: Findings Overview that gives a summary of headline findings from across the datasets, in order to set the scene in advance of deeper elaboration in the three thematic chapters.

Chapter 6: Thematic chapter – Knowing: Transforming epistemic goals and relationships with knowledge.

Chapter 7: Thematic chapter – Evaluating: Social construction and appraisal of goal achievement.

Chapter 8: Thematic chapter – Empathising: Reciprocal emotion regulation for complex goal achievement.

Chapter 9: Discussion and implications chapter that draws together key themes and presents an integrated model and a framework for emotion-informed STEMM curricula.

Chapter 10: Conclusion chapter that revisits research questions in light of findings, highlights theoretical and methodological contributions and presents recommendations for policy and practice.

2. Literature Review

2.1 Chapter introduction

This chapter sets out what is known, and could usefully be known, about emotion and its role in university learning and teaching, with a specific focus on collaborative, science-based contexts. It is structured to reflect the funnelling process I have taken to approaching the vast and varied body of literature that contributes to this understanding. It begins by examining understandings of what emotion is, in relation to this study. Next, I identify key literature that shapes understanding of emotional experience in learning and teaching, and specifically the STEMM and collaborative learning contexts. In line with a subjectivist inductive approach (Varpio et al., 2020), the Literature Review and subsequent Theoretical Framework have been developed from a tentative framework and refined as my understanding has developed through iterative engagement with my data and literature. This chapter also begins to establish gaps in our understanding of this phenomenon, why this study is relevant and how it contributes to what is already known and used. Together with the Theoretical Framework, it connects theories and empirical studies to frame a study that seeks to explore new territory regarding the emotional interconnectedness of STEMM university student peers' and teachers' learning and teaching experiences.

2.2 Emotion as a contested and evolving phenomenon

There is a wide range of research on emotion spanning many disciplines, including neuroscience, psychology, sociology, philosophy and education, “[y]et there is no consensus on a definition of the term *emotion*, and theorists and researchers use it in ways that imply different processes, meanings and functions” (Izard, 2007, p260). This has led to a diversity of approaches in conceiving, categorising, labelling and researching emotions. Emotions are commonly understood as multifaceted phenomena that involve interacting affective, cognitive, physiological, motivational and expressive components (Pekrun and Linnenbrink-Garcia, 2014). This section gives brief background context to key ideas and differing, evolving views, and forms the basis of the theoretical and methodological choices I have made in this study.

2.2.1 Enduring ontological divisions

Scholars have been trying to understand and theorise about emotion since Plato and Aristotle and have progressed through a series of philosophical positions on the nature of emotion. *Emotion* as a term entered the English language in the 17th and 18th century and began to be studied in the 19th century (Scarantino, 2016). Over the centuries and between theorists, there have been many different opinions on what emotions are, with several key ideas still informing current understanding and contributing to divergent ontological perspectives. Key ontological division centres on disagreement over whether emotions are 'natural kinds', with observable characteristics and neurobiological signatures, similar enough to fit into one category, and therefore be researched as similar entities, or not (Barrett, 2006). In accordance with essentialist beliefs, "some scientists hypothesize that each emotion category is characterized by a distinctive set of experiential, behavioural, muscular, cognitive, and autonomic responses... that distinguish instances of one category from another" (Lindquist et al., 2013, p1). Conversely, other emotion scientists argue that emotion concepts are not universal truths but are constructed and shaped by language and experience in sociocultural contexts (Gendron et al., 2014). They argue that emotions are adaptive and that we actively construct them to accommodate to a variety of different and potentially demanding situations (Immordino-Yang, 2016). It is this social constructionist perspective that underpins this present study.

The following brief overview gives insight into how understanding about emotion has developed from a historical perspective, including distinct influential thinkers, to form the basis of persisting ontological division. According to Scarantino (2016) this can be organised according to three broad traditions: the 'feeling tradition', the 'motivational tradition' and the 'evaluative tradition'.

Broadly, those developing the 'feeling tradition' have proposed that emotions are bodily perceptions or sensations. For 17th century philosopher René Descartes these were passions or "psychic atoms" (ibid, p7) produced by the soul. It is his theory, that the natures of mind and body are entirely different and could exist independently, that gave rise to the enduring effects of Cartesian dualism (Thibaut, 2018), including the distinction between rational thought and emotionality. In the late 1800's, psychologist William James introduced the constructionist approach, positing that feelings result from physiological changes, rather than the other way round. For example, we feel "afraid because we tremble" (James, 1884, p190, cited in Scarantino, 2016, p12) rather than trembling because we feel afraid.

Technological developments, allowing measurement of neural activation in the brain, have advanced James' emphasis on autonomic physiological changes (Scarantino, 2016).

Contemporary neo-Jamesians and psychological constructionists, such as James Russell

and Lisa Feldman Barrett, have built on James' view, arguing that emotions are the result of complex interplay between neurophysiological changes and cognitions related to these changes (Posner et al., 2005, Barrett, 2006). This principle, around which many psychologists' thinking converges, is captured in the circumplex model (Russell, 1980), that depicts emotions as based on positive / pleasant and negative / unpleasant valence and varying levels of arousal or activation. Barrett (2017) has elaborated this, further emphasising each individual's active role in constructing and categorising emotion concepts. For example, she posits that we categorise a core affective state of high displeasure and high arousal under the concept of 'fear' and a core affective state of high pleasure and high arousal under the concept of 'happiness'. Some neo-Jamesians, such as Antonio Damasio, argue, unlike James, that emotions and feelings are distinct and have different roles: "an emotion is a collection of changes in body state connected to particular mental images that have activated a specific brain system" (Damasio, 1994, p145) and feeling works as 'sentinels', informing the mind about the state of the body and giving the mind an incentive to act on those signals (Damasio, 2021).

The 'motivational tradition' has emphasised the role of emotion in motivating behaviour, whether that be an angry facial expression or running away in fear. Contributors to this tradition included controversial behaviourist John B. Watson who, in 1913, argued that in order for psychology to be considered a natural science, it should define emotions according to behaviours and the stimuli causing them. He believed that most emotions were learnt (Scarantino, 2016). Conversely, in Charles Darwin's (1872) evolutionary-oriented yet essentialist view, published in 'The Expression of the Emotions in Man and Animals', he had asserted that all humans, worldwide, exhibit and recognise facial expressions of emotion without training (Barrett, 2017). According to Darwin, emotion related to, and communicated, motivation, emotion came first and expression followed, for example, bared teeth expressed already felt anger (Scarantino, 2016). In the late 1960s, anthropologist, Paul Ekman's, influential cross-cultural research unintentionally offered support to 'basic emotion theory' by claiming to provide evidence that some emotions are innate, hard-wired and universal across humans. He categorised discrete basic emotions - joy, distress, anger, fear, surprise, disgust - as having specific neural circuits residing in the subcortex of the brain and higher cognitive emotions - love, guilt, shame, embarrassment, pride, envy and jealousy - located in the brain's neocortex (Evans, 2003). This reinforced the 'classical' view of emotions as objectively observable natural phenomena, a view that underpins artificial intelligence facial recognition technology (Barrett, 2017). Social constructionists, such as Parkinson, Averill, Van Kleef and Mesquita have pursued research from an evolutionary perspective, that

understands emotion as fulfilling social functions and acknowledges cultural differentiation (Scarantino, 2016).

The 'evaluation tradition' has understood emotions as processes that involve an interpretation or judgement of a situation. These can be distinguished as two, often conflated, approaches: the *constitutive approach*, which understands emotions to *be* evaluations of a situation and the *causal approach*, which considers emotions to be *caused by* evaluations of a situation (Scarantino, 2016). Proponents argue that this more cognitive emphasis enables consideration of a) the appropriate or inappropriate direction of emotions on an object or focus (e.g. judging an individual to be inappropriately angry with another when the fault is their own) and of b) how emotions are caused. The first argument was taken up by philosophers and the second by psychologists as appraisal theories (ibid). Appraisal theories' emphasis on cognitive appraisal of a stimulus and resulting action tendencies offer explanations for why different individuals, with different experiences, expectations and self-efficacy beliefs informing their appraisal, and different goals relating to their actions, experience different emotions (Moors, 2017). Distinct appraisal theories endorse both a discrete emotions view (Flavour 1) and a dimensional view of emotions as encompassing an infinite range of subsets, organised according to factors such as goal-based appraisal (Flavour 2) (ibid).

As well as to highlight important ontological division, I have included this overview of broad traditions to help educational practitioner readers to gain a sense of the breath and diversity of emotion theories represented in the literature. This is strongly caveated by words of caution from Barrett (2016) that such categorisation of emotion theories can ignore inter-category distinctions and between category similarities. Based on my positioning as an educational developer, I see powerful utility and potential for impact in understanding emotions experienced by individuals as being dynamically and socially constructed through interactions between people, including teachers and students. Accordingly, my work draws on what Scarantino, possibly reductively, categorises as the 'feeling tradition' to explain how emotions are constructed (e.g. Barrett), the 'motivational tradition' to analyse the social function that emotion fulfils (e.g. Parkinson) and the 'evaluation tradition' to consider how appraisals, including in relation to social objects and goal achievement, contribute to construction of emotion. I elaborate and justify this approach in my theoretical framework.

2.2.2 Recent neuroscientific contributions

Psychologists have been increasingly drawing on advances in neuroscientific understanding of how emotions may occur and be experienced at a biological level, to inform their thinking. This is illustrated by influential appraisal theorist, Scherer's (2009), 'component process

model' illustrates the complexity with which humans process appraisal criteria at four interacting neurophysiological levels, in order to interpret their situation:

“(a) a low-level neural circuit [involving]... genetically determined...pattern-matching, (b) a schematic level, based on memory traces from social learning processes and occurring in a fairly automatic, unconscious fashion; (c) an association level, involving various cortical association areas, which may occur automatically and unconsciously or in a deliberate, conscious fashion, and (d) the conceptual level, involving propositional knowledge, and underlying cultural meaning systems, requiring consciousness and effortful calculations in prefrontal cortical areas” (Scherer, 2009, p1314).

It is valuable to reflect this integration of neuroscientific and psychological explanations within the framing of this study in order to develop a more holistic and robust picture of the role of emotion in STEMM university learning and teaching. Many affective neuroscientists have moved away from the strict localisation of emotional function within the brain (for example, fear being localised in the amygdala), to largely now accepting that there are no neural centres in the brain for emotion categories, as previously thought. Instead, the field of affective scientists ascribing to a psychological constructionist and neural constructionist view of emotion have moved towards a neural network-based approach to understanding and researching emotion (Lindquist, 2023). This view recognises that within emotion categories, for example, of anxiety, sub-sections of anxiety are mapped onto different neural pathways (ibid). However, this is not a universally accepted view across neuroscience and longstanding ontological debates continue, with scientific, objective neuroimaging evidence being collected and interpreted in support of both discrete ‘basic emotion theory’ tradition and constructionist perspectives. This includes continual adjustment of conceptualisations in light of advances in neuroscientific understanding, as Celeghin et al. (2017) illustrate:

“the concept of basic emotions can still be fruitful, if updated to current neurobiological knowledge that overcomes traditional *one-to-one* localization of functions in the brain. In particular, we propose that the structure-function relationship between brain and emotions is better described in terms of pluripotentiality, which refers to the fact that one neural structure can fulfill multiple functions” (p1).

To give a sense of balance of perspective held by emotion scientists, in 2016, Ekman conducted a short survey amongst 250 scientists identified as studying emotions. He found

that: “In response to the question “which of the following best captures your orientation toward emotion in your research?”, 49% chose “discrete emotions (anger, fear, etc.) combining both biological and social influences,” 11% chose “emotions as constructed, either socially or psychologically to fit current conditions,” and 30% indicated they used both approaches” (Ekman, 2016, p33). He also noted that those researchers studying emotion using qualitative approaches were not invited to complete the survey but, that had they been, they may have very different perspectives about the nature of emotion.

With this brief synthesis of key literature regarding the nature of emotion, I aim to have indicated how understanding about emotion has developed over centuries and across contributing disciplines and fields, that in turn influence each other and current understandings. With such an everyday phenomenon as emotion, this includes the understandings of lay people, including students and teachers, and informs the way they make meaning of emotion in learning and teaching, including how active a role they have in influencing emotion. This diversity of understandings contributes to making emotion a complex and challenging phenomenon to research and communicate. For this reason, in my Theoretical Framing chapter I clearly set out which of these conceptualisations are valuable for thinking about emotion in learning and teaching and will frame my study.

2.3 Emotions in learning

Emotion is evident in every learning setting. “Students may experience confusion over challenging concepts, joy at grasping them, anxiety about assessment and pride in group projects. Similarly, teachers can feel excitement or apprehension about using new techniques and frustration at perceived lack of student engagement (Ippolito and Kingsbury, 2024, p1). Yet, dating back to Plato, the prevailing view amongst Western thinkers has been to treat learning, and specifically cognition, the mental process of “acquiring knowledge and understanding through thought, experience and the senses” (OxfordLanguages, 2023) and emotion as separate. This was largely because emotion was considered an obstacle to intelligent thought (Evans, 2003). Heavily influenced by Cartesian dualism, contemporary education still privileges ‘the rational’ as opposed to affective dimensions of academic engagement (Beard et al, 2007). Even though attentive teachers recognise that emotions affect their students’ learning, this perceived duality has continued to influence education, obscuring the underpinning influence of emotion on cognitive functioning (Immordino-Yang and Damasio, 2007). From a psychological perspective, there is substantial empirical evidence that not only is emotion an unavoidable feature of stepping into any learning

setting, it is also closely associated with academic goal achievement and personal development (Pekrun and Linnenbrink-Garcia, 2014). Cunningham et al. (2013) argue that cognition and emotion are inseparable as cognition covers all information processing, including of the experience of emotion. These ideas will be considered in some detail in the Theoretical Framework chapter.

Continual developments in neuroscience offer an increasingly persuasive and insightful evidence-base for the strong and reciprocal connection between cognition and emotion in learning (Zull, 2006, Immordino-Yang et al., 2019). “In the last 25 years, thinking has progressed from a perception that emotion obstructs learning, to understanding that it is ‘neurobiologically impossible’ to engage in cognitive processes such as paying attention, remembering material, problem-solving and decision-making without emotion (Immordino-Yang, 2016)” (Ippolito and Kingsbury, 2024, p1). Immordino-Yang, affective neuroscientist and educational psychologist, has made significant progress in bridging the methodologically challenging gap between neuroscientific research understanding and educational practice. Based on her group’s research, she explains that “cognition, emotion, culture and sociality are intimately integrated in the brain...impacting each other dynamically, in real time” (Immordino-Yang, 2020, np). Figure 2.1 illustrates how thinking and development, including social and emotional learning, are supported in the brain through a dynamic interplay that involves three major brain networks: the Salience Network, the Default Mode Network and the Executive Control Network.

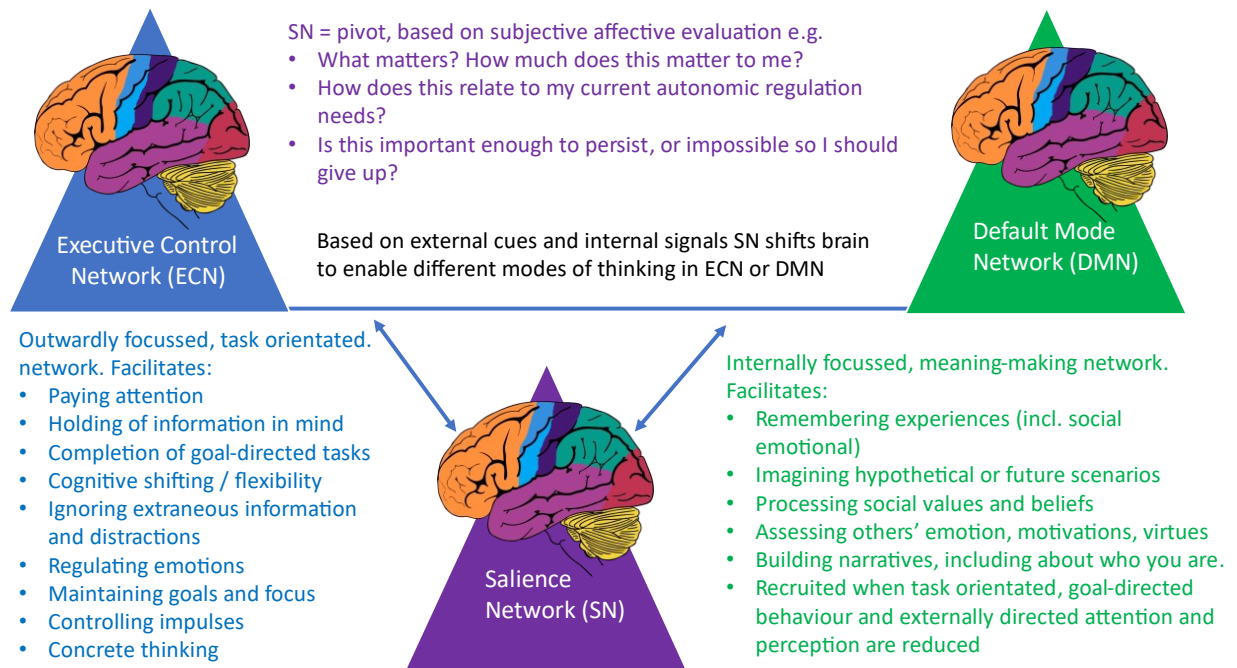


Figure 2.1: Interaction between three major brain networks supports social and emotional learning, based on Immordino-Yang et al. (2019)

Source of brain image: [National Institute of Neurological Disorders and Stroke](#) (National Institutes of Health, U.S. DHHS)

As Immordino-Yang et al. (2019) explain:

“The Salience Network weighs emotional relevance and perceived importance and urgency of information to facilitate switching between mindsets supported by the inwardly focussed meaning-oriented Default Mode Network and those supported by the outwardly focussed, task oriented Executive Control Network” (p189).

Through her work, Immordino-Yang urges educators to acknowledge the pivotal nature of perceived salience, or relevance, by learners. Immordino-Yang et al. (2019) also highlight the neurological incompatibility of conducting a task oriented, goal-directed activity, such as listening to the teacher, while at the same time carrying out a meaning-making activity, such as reflecting on the success of a task. This is because the Default Mode Network does not tend to coactivate with the Executive Control Network and is recruited only when goal-directed behaviour and external perception is reduced. As Figure 2.1 illustrates, emotion and cognition are not separated into regions of the brain in terms of structure or function, as previously thought, but are integrated within and across brain networks. Furthermore, as individuals engage in thinking, feeling and meaning making, supported by these three networks, they are shaping the organisation of their brain networks over time. This happens

in the context of socio-cultural interactions and associated emotional experiences which contribute to shaping patterns of neural functioning (Immordino-Yang, 2020). This, Immordino-Yang et al. (2019) argue is “*why and how* academic learning may be so dependent on culturally situated social relationships and emotional experiences” (p186). These brain developments occur throughout life and are particularly relevant at times of transition and hormonal adjustments. During late adolescence, the stage many UG students are in, the brain prunes connections leading to greater brain efficiency (Giedd et al., 1999). There is also an increase in “neural “cross-talk” between regions further apart in the brain, especially those involved in higher level cognition and cultural values, emotions and beliefs” (Immordino-Yang et al., 2019, p194) . Immordino-Yang (2020) highlights that this period offers a key opportunity for helping learners to rework networks for future growth and building habits of mind. Importantly, it is also a period of vulnerability when an individual’s development is particularly susceptible to their perception of the social, emotional, cultural and cognitive context in which they find themselves. Despite these neuroscientific advances, understanding of how brain structure and function supports learning and the central role of emotion in this, has had very little influence on educational practice. An exception is universal design for learning (Meyer et al., 2014), a framework to promote inclusive teaching and learning approaches. Overcoming the disconnect between affective neuroscience and educational practice involves challenging entrenched notions including that, rather than emotion interfering with educational achievement and rational thought, emotion is the basis for thought and that socially constructed emotion influences academic development (Peters, 2015). This is especially relevant in high achieving STEM contexts (Gotlieb et al., 2016), so has significant importance for this present study.

Combining traditional, observation-based, psychological ideas that influence educational understanding, such as Piaget’s theory of assimilation and accommodation, with corresponding neurobiological ideas that explain how this process is neurologically supported by diverging and converging zones in the brain, offers a fuller explanation how we learn (Huberman and Immordino-Yang, 2023). It gives insight into how, when things do or do not happen as we expect, making meaning and learning occurs emotionally and cognitively in an integrated way (ibid). This, more obviously scientifically-informed explanation, may be more persuasive in STEMM contexts.

2.3.1 Emotions in STEMM university learning and teaching

It is evident that “[e]ven in scientific disciplines, traditionally considered objective, rational, dispassionate, with little place for emotion, the catalyst to start and motivation to persist in

learning and scientific enquiry is emotion” (Ippolito and Kingsbury, 2024, p1). Furthermore, emotions enable us to adapt to new learning situations: “Emotions are skills – organized patterns of thoughts and behaviours that we actively construct in the moment and across our life spans to adaptively accommodate to the various kinds of circumstances, including academic demands” (Immordino Yang, 2016, p20). Despite calls to pay attention to the role of emotion in university learning and teaching over the last 10 years (Beard et al., 2013, Gilmore and Anderson, 2016, Quinlan, 2016), this has been slow to gain momentum either as deliberate educational practice or as an area of adequately theorised educational research. In the particular case of scientific, technological and engineering university disciplines, this has been attributed to a number of reasons that I will now consider.

All disciplines evolve their own approaches to teaching and learning that are intimately related to their beliefs about knowledge and their educational goals, sometimes referred to as signature pedagogies (Shulman, 2005). Individual departmental cultures also evolve their own distinct characteristics. What all of the STEMM contexts have in common, that is relevant to this study, is their epistemological basis in science and scientific reasoning. This may make the Cartesian dualism separating mind and body, rational and emotional particularly influential. Despite this, existing literature reflects how readily students articulate their emotional experiences in the pursuit of learning science, even when it is not directly solicited (Charalambous et al., 2020). It seems particularly important at a time when we are seeking both to increase numbers of students studying STEM disciplines in HE and to diversify student cohorts by making the study and practice of STEM-based endeavour attractive to traditionally underrepresented groups (Campaign for Science and Engineering, 2023), that we pay attention to emotional experiences (Sinatra et al., 2014). Medicine, as a university discipline, has its own, potentially more complex relationship with the role of emotion. Medical students’ development of emotional intelligence and empathy in relationships with patients is now a General Medical Council (2020) strategic priority and is embedded in medical curricula (Roth et al., 2019). Despite this, evidence suggests that medical students become less empathetic over the course of their degree (Howick et al., 2023) and do not always feel adequately supported to develop the emotional competence required for emotionally challenging clinical practice (Bolier et al., 2018).

Having worked with educators and students in science-based disciplines for 23 years, I agree with Sinatra et al. (2014) that “Science is often mischaracterized as a dispassionate discipline...Like all human endeavors, science is conducted and learned with the full range of emotions present in all human pursuits” (p415). So why does this Cartesian dualism seem to persist, giving the veneer of emotional neutrality to learning and teaching in STEMM HE?

It is illuminating here to consider specifically engineering disciplines as a sub-category within this wider science-based category of STEMM. Growing interest in the role of emotion in Engineering Education is evidenced by specific focus, such as the European Journal of Engineering Education's special edition 'Emotions in Engineering Education' and Lönngren et al.'s. (2024) systematic review. This interest has been precipitated, in part, by emphasis in engineering curricula for graduates to be prepared to address complex, real-world problems (Kellam et al., 2018), by persuasive neuroscientific evidence that emotion is integral to scientific thinking, as well as a desire to challenge limiting dominant discourses and stereotypes (Lönngren et al., 2023). Prominent themes in Emotions in Engineering Education (EEE) literature include students' academic emotions, emotions and ethics, emotional intelligence, and mental health (Lönngren et al., 2023). Going forward, Lönngren et al. (2023) highlight the need for a more theoretically underpinned and methodologically intentional approaches to EEE. They appeal for less emphasis on emotions as intrapersonal phenomena that learners and teachers should learn to control in order to "conform with dominant emotion norms irrespective of whether those norms are beneficial for teaching, learning and responsible engineering practice" (p168). They also argue for critical engagement with often-cited concepts such as emotional intelligence that, when used uncritically and seen as a skill, rather than the set of cognitive abilities originally intended by Mayer and Salovey (1993), can perpetuate dualistic understanding of emotion as distinct to reason. Instead, amongst other directions, they encourage more research on emotions in learner-teacher relationships, that includes teachers' emotional experiences and that adopts a social constructionist perspective (Lönngren et al., 2023).

Kellam et al. (2018) attribute the absence of explicit reference to emotion in engineering teaching and associated pedagogic research to biases in relation to disciplinary identity and knowledge:

"Engineering faculty and professionals prefer to favour conceptions of engineers as rational decision makers and problem solvers over conceptions of engineers as people who use their feelings and emotions to make decisions and solve problems...Consequently engineering faculty have favoured focussing educational endeavors on students acquiring separate knowing, which conceptualizes knowing as being analytical, objective, detached and adversarial over connected knowing, which conceptualizes knowing as involving perspective taking, empathising and feeling" (p1).

It is interesting that they identify professional identity stereotypes held by both faculty and professional engineers as influencing curriculum content and approaches. This contrasts with Strobel et al.'s (2013) findings that practicing engineers conceived empathy and care to be core components of engineering practice and beneficial dispositions to develop in students. Conversely, engineering faculty viewed their development to be an unnecessary addition to overcrowded curricula, with faculties' conception of empathy related more closely to their support for students (Strobel et al., 2013). Kellam et al. (2018) also attribute the lack of attention to emotionality in engineering curricula to the higher value that engineering *science* holds for faculty and students over engineering *design*, where more 'connected knowing' or affective dimensions can be learnt. This is commonly reinforced by curriculum design and can serve to shift the perceptions of students who arrive valuing 'connected knowing' and more affective dimensions. Lönngren et al. (2021) illustrated how engineering students' discourse about a wicked sustainability problem involved emotional positioning that both strengthened and challenged dominant discourses about the need to maintain rational and objective decision-making in engineering by ignoring affective-informed perspectives.

There has been some focus on engineering students developing emotional competence through group working and this is generally with a focus on preparing them for professional practice as graduates (Chisholm, 2010). Little attention is given to the potential of collaborative projects for enabling students to develop emotional awareness that supports academic experiences and achievement (Casado et al., 2016). This is surprising, given that group-based projects are an important feature in engineering curricula and typically provoke many contrasting emotional experiences. These include anxiety related to uncertainty and lack of control (Strauss et al., 2011) and frustration over perceived unequal contribution between peers (Popov et al., 2022).

Similarly, in the field of natural sciences, research into emotion has tended to focus on individualised perspectives on learners' emotional experiences. Examples include Bodin and Winberg's (2012) quantitative study into emotions involved in numerical problem-solving by second year physics students and Schubert et al.'s (2023) quantitative study on the role of epistemic emotions in UG maths students' proof construction. Flaherty's (2020) review of affective chemistry education research, based on 91 studies related to emotion in learning published since 2020, sought to understand how students feel when learning chemistry and possible influences on performance. Both Lönngren et al.'s. (2023) work in engineering and Flaherty's (2020) interrogation of chemistry education show that emotion often appears to have been studied as incidental phenomena, rather than being the intentional, primary focus which included "attitudes, self-efficacy, self-concept, expectations, values, interest, motivation, effort beliefs and achievement emotions" (p699). This may reflect a lack of

confidence about the merits of researching purely emotion in science learning and tends to result in undertheorized examination of emotion as data (Lönngren et al., 2023). Flaherty (2020) critiques the predominance of quantitative studies (85%), primarily aimed at comparing affective states across cohorts, assessing impact of interventions and correlating affective states with exam outcomes. She highlights a need to increase the proportion of qualitative studies from only 5%, if the field is to understand the highly subjective and unstable nature of emotions and their implications for learning more broadly and comprehensively.

Also of relevance is the momentum gathering around the need to acknowledge the important role and frequency of failure in scientific endeavour, particularly in terms of “the failure to observe an expected outcome” (Guttinger and Love, 2019, p48765). If we accept that failure is both an inevitability and strength of scientific endeavour (Firestein, 2015), we need to be more open with students about aspects such as their failed laboratory experiments and what can be learnt from these experiences (Lanni, 2021). In turn, “we need to equip learners to accept and harness the discomfort and difficult emotions that failure may provoke” (Ippolito and Kingsbury, 2024, p2). Goetz et al. (2006) argue for the value of exploring such emotions and their impact on learning in discipline specific domains. Valuable inquiry could focus on failure in science-based learning, which, although clearly inherent and important for learning, can hit science students very hard at university level. This may be because of the perceived absolutist nature of scientific knowledge and binary feeling of being right or wrong, which is arguably less powerful and absolute in other disciplines. Finally, understanding the role of emotion could enable us to capitalise on those that are adaptive for scientific and technical learning and for sustaining motivation towards careers in scientific fields (Sinatra et al., 2014).

In summary, there is a growing body of literature, predominantly based on quantitative research, to evidence the significant impact of emotion on STEMM university student learning experiences and outcomes. It also suggests a need for STEMM-educated graduates who can intentionally use emotion alongside cognition to guide problem-solving, decision-making and social interactions in ambiguous contexts. The literature also indicates that, despite the enduring effect of Cartesian dualism, at least at a symbolic and stereotypical level, consideration of the affective dimension is not completely absent from the day to practice of learning and teaching in university STEMM contexts. This study can usefully contribute to this body of literature by intentionally and qualitatively investigating the interacting emotional experiences of STEMM university learners and teachers.

2.4 Emotional influence between students and teachers

Despite its relevance for educational effectiveness and wellbeing (Frenzel, 2014), there are still very few studies that shed light on how students and teachers impact each other's emotions in the process of learning and teaching. This is largely because it is a difficult relationship to 'measure', particularly according to a quantitative paradigm, as Pekrun (2021) explains:

“For teachers to have an effect on students, the minimum needed is that teachers generate some behavior, that this behavior is perceived by students, and that these perceptions influence students' own cognition, emotions, and motivation. As such, teacher effects depend on the functioning of mediating processes, and research on these effects depends on adequately capturing these processes” (p316-317).

Bardach and Klassen (2021) highlight the risk of the signal being lost and consistent effects not being found when investigating how teachers' affective dimensions, such as motivation, influence student outcomes during these complex sequences of interaction. I suggest that qualitative research approaches, with their more exploratory, interpretative focus, are less reliant on a continually clear signal.

Existing research includes studies investigating the effects of teaching approach and teacher-created atmosphere on students' emotional experiences. For example, Hartikainen et al.'s (2022) qualitative analysis of interviews with 26 engineering UGs revealed that, as well as the design and facilitation of learning activities, opportunity to develop relationships with peers and teachers contributed to positive emotional experiences. Students also related their emotional experience to whether they perceived the teacher to be bored or enthusiastic. Mendzheritskaya and Hansen (2019) found that teachers' emotions differentially influenced Russian and German university students' judgements: “Both groups of students considered the lecturer to be more conscientious, cautious, and understanding when he showed pity than when he showed no emotion or anger” (p1793). Quinlan (2019b) found that amongst 706 first year students across 12 different lectures, including four science lectures, along with students' own individual interest, “their perceptions of their teacher's enthusiasm, approachability and knowledge were the strongest predictors of situational interest” (p1781). Similarly, Frenzel et al. (2019) demonstrated in a study involving 483 university students majoring in Education or Economics that when an actor posing as an assistant professor displayed high enthusiasm this had positive effects on student evaluation of clarity and structure and on reported in-session emotional experiences.

Frenzel et al. (2018), in “the first [study] to provide longitudinal evidence of reciprocal emotion transmission between teachers and students” (p628) found positive relationships between fifth grade teacher enjoyment, their students’ perceptions of teacher enthusiasm, student enjoyment and teacher perception of student engagement.

In terms of student peers’ emotional influence on each other, the effects of group-level emotional interaction and regulation on secondary school age science learners have demonstrated effects on individual emotional experience (Mänty et al., 2020) and regulation of learning (Tormanen et al., 2023). Using a video-based approach, Järvenoja et al. (2019) investigated emotion regulation (ER) in challenging collaborative learning between 62 university students, collaborating in groups over a six-week maths course. They identified how different challenges activated co- and socially shared ER and that collaborating students used four types of strategies; increasing awareness, encouragement strategy, social reinforcement and task structuring. However, these were first year teacher education students, who may be expected to be more aware of interpersonal interaction than STEMM students. They were also not asked to articulate their regulation strategies, as in this present study, rather this was interpreted by researcher, based on video footage.

In the under-researched area of university teachers’ emotional experiences, negative affect induced by learner behaviour has been identified as relating to specific interpersonal activity. These include facilitating classroom-based interaction (Lahtinen, 2008), assessing student work (Myrsky et al., 2020) and reactions to student evaluation of teaching (Uijtdehaage and O’Neal, 2015, Lakeman et al., 2022). Valuable considerations also relate to university teachers’ emotional labour (Constanti and Gibbs, 2004, Lawless, 2018). In this context, emotional labour may result when students, frustrated, angry or saddened by the mismatch between their learning goals and actual achievement, target these difficult emotions at the teacher, thus burdening them with an emotional load (Lahtinen, 2008). It may also occur when a teacher’s role expectations and goals misalign with changing institutional priorities (Burke, 2017). Positive emotional experiences relate predominantly to positive relationships with students (Quinlan, 2016), ideally characterised by emotional qualities such as warmth, trust and admiration (Tormey, 2021). Other teaching staff gain their satisfaction from delivering informative lectures, particularly if they have a content focussed conception of teaching practice (Postareff and Lindblom-Ylänne, 2011). Through university teachers’ poems about their values and emotions, Quinlan (2019a) explores the tensions they perceive in developing caring relationships and connecting with students emotionally in current HE contexts. Frenzel et al. (2021) identify how teacher emotions indirectly impact on learners and their emotional experiences because of the important effects they have on

teaching behaviours, such as choice of pedagogic strategies.

2.5 Emotion in active and collaborative learning

Active learning is a term used to describe a process that involves students in actively constructing their own understanding and requires meaningful interactions between student and teacher, and between student peers (Bovill, 2020). Based on their synthesis of research on active learning in STEM educational contexts, Freeman et al. (2014) highlighted the substantial impact of active learning on academic performance, as compared to the control condition of relatively inactive lecture-based learning. Evidenced benefits include, not only development of subject-based competence and critical thinking skills, but also intercultural competence and openness (Mayhew et al., 2016). These include graduate attributes that universities are required to evidence in order to demonstrate they are supporting their students' educational gain (Fung, 2024). Marshall et al. (2014) recognise active learning as involving both cognitive and emotional engagement in learning activities. Indeed, active learning in STEMM contexts should aim to challenge understanding and requires "recognition that obtaining the 'wrong' answer, although intellectually uncomfortable, can be a necessary and positive step in progression to sustainable learning" (Imperial College, 2017, p9). This discomfort can lead to a need for regulation of emotion in learning (Harley et al., 2019) and this has implications for university learners' and teachers' wellbeing (Riva et al., 2020).

Collaborative learning involves students working together in small groups towards achievement of goals and offers opportunity to rehearse new concepts, share different perspectives and gain peer feedback (Lobczowski et al., 2021). I argue that none of these are emotionally neutral processes. Collaborative learning strategies used in STEMM contexts include team-based learning (Greetham and Ippolito, 2018) and group-based projects (Sorce et al., 2024). Despite the existence of these pedagogical strategies in STEMM curricula for a number of years, large scale "[m]odern curricula reform movements have put an emphasis on both using collaboration as pedagogy and privileging collaboration skills as a desirable learning outcome (Lobczowski et al., 2021, p12) .

Active and collaborative learning represent a shift from the teacher-focused approaches traditionally favoured by hard science and engineering disciplines (Hartikainen et al., 2022) and a (re)introduction of learning that challenges students through engaging with real-life scenarios that promote higher-order thinking such as analysis, synthesis and evaluation (Lima et al., 2016). This enhanced interaction and need to collaborate means that emotions

are more evident to students and teachers (Charalambous et al., 2020). Many students lack the skills to successfully engage in collaborative learning and teachers often underestimate this, which can lead to a reciprocal relationship between negative emotion and group functioning (Lobczowski, 2020). More open, less structured learning situations that require students to collaborate and socially construct knowledge are challenging, with even high achieving students demonstrating little spontaneity in co-regulating learning with peers (Volet et al., 2009). Successful collaborative learning requires students to consider their peers' goals, reconsider and adjust their own multiple goals and develop shared goals, a process that involves significant social construction of emotion (Järvenoja et al., 2013). Burke and Crozier (2013) observe that teachers can also experience diverse and contradictory emotions. This can lead teachers to overestimate their students' resistance to active learning (Andrews et al., 2020). I argue that this increased emotional interaction, particularly in STEMM contexts, where there may be less awareness and experience in working with emotion, requires evidence-informed strategies to increase understanding and equip learners and teachers to work with emotions. For example, Kandiko-Howson and Kingsbury (2024) highlight how in STEM disciplines that are assumed to be emotionally detached, a feeling of belonging can be fostered through more intentionally collaborative "STEM ways of thinking" (p9).

2.6 Chapter conclusion

This chapter presents an analysis and synthesis of selected literature to map what is currently understood about emotion in UG university learning, and specifically in collaborative, active learning in STEMM contexts. It began by highlighting contrasting perspectives on the nature of emotion that are important to consider when developing a theoretically underpinned and coherent study on emotion in education. I identified literature that evidences valuable relationships between emotion and learning, including in STEMM contexts specifically. I identified gaps in empirical evidence, and particularly rich qualitative insights, regarding the emotional experiences of both students and teachers in STEMM HE and interpersonal emotional influence through collaborative approaches, despite this being increasingly relevant. I will now present a theoretical framework which builds on the literature review to create a lens through which to study how students and teachers socially construct emotion in STEMM education settings, what influences these processes and how this influences learning and teaching experiences.

3. Theoretical Framework

3.1 Chapter introduction

In the previous chapter, I brought together literature that maps current thinking and highlighted gaps in understanding about learners' and teachers' emotional experiences in active and collaborative STEMM HE settings. This chapter identifies and connects two theoretical areas that are currently influential in the research of emotion, and that I consider highly relevant for shaping and scaffolding this present study, for making sense of the data and for addressing the research questions. I have worked to pull together emotion theories and ideas that are informed by several fields of study, and productively grouped them under the categories of 'Emotions as goal-based' and 'Emotions as social'. This is important because a limitation of research on emotions in education can be that theoretical assumptions about emotion are not explicit and fail to recognise the inherent complexities (Zembylas, 2007). Furthermore, through this study, I aim to develop an emotion-informed conceptual framework that is relevant and accessible for use by practitioners to guide their curriculum design and teaching practice. As indicated in the previous chapter, in the majority of emotion in education literature, emotional experiences are considered from the students' perspective. Where teacher perspectives are considered, this is in isolation from analysis of student emotion. In order to more fully consider emotion in university learning and teaching contexts from a social constructionist perspective, which recognises that we construct emotion through our interaction, I have developed a framework that enables consideration of emotional experiences between student peers *and* teachers.

3.2 Emotions as goal-based

The theoretically and empirically informed understanding about relationships between emotions and goal attainment is central to influential thinking and research about emotion in neuroscience, psychology and education. Goals and their achievement are highly relevant to HE contexts, where people interact to develop themselves and each other academically. In this context, goals may be academic-related, identity-based, social or even related to emotion itself. They may be proximal, relating to the current situation or distal, relating to the future (Harley et al., 2019). This section will connect relevant goal-based theories that contribute to understanding of emotional interactions between university students and teachers, as they pursue their individual and collective learning and teaching goals.

3.2.1 Constructionist perspectives on emotions and goals

In a radical departure from the commonly held, essentialist-informed perspective, of discrete emotions being triggered in response to an event, Barrett (2017) argues that “Emotions are not reactions to the world; they are your constructions of the world” (p104). Based on neuroscientific constructionist, as well as social and psychological constructionist, perspectives, her ‘Theory of constructed emotion’ explains how an individual uses internal and external information, prior experience and their knowledge of emotion, for example fear, to rapidly construct an emotion concept to make sense of the situation (Barrett, 2017). Automatically physiological sensory information is transformed into psychologically meaningful information by combining with contextual and experiential knowledge of emotions (Lindquist and Barrett, 2008). Key to this is that “[e]motion concepts are goal-based concepts” (Barrett, 2017, p92). That is, construction of emotion concepts are informed by an individual’s future goals and experience of tackling past goals. Furthermore, this perspective conceives of emotions as tools for assisting individuals to achieve their goals (Givens and Wilkinson, 2022). This goal-based orientation can helpfully shift the emphasis from seeing emotions as irrelevant or problematic, to being informative, helping us to refine our goals. When applied to a research context, this perspective means that “[r]ather than claiming that any emotion is globally helpful or harmful, affective scientists chart contexts under which emotions serve or fail people’s goals” (Zaki, 2017, np).

In the context of university learning, a student’s goal for going to a seminar might be to learn from a teacher’s explanation of a difficult concept and/or to find out about how peers are progressing. Depending on their physiological state, together with prior and current experience of that topic, class and teacher, they might sense a core affect of pleasure and activation and conceptualise this as curiosity. Or they might sense a core affect of displeasure and activation and conceptualise this as anxiety. Their predicted and perceived success in achieving their goal will contribute to their dynamic emotional experience, as their constructions are continually refined through predication and feedback loops between external input and their brain (Barrett, 2017).

Emotion also actively and dynamically supports regulated learning goals. By calling up relevant information and memories, inciting attention and motivation, recruiting appropriate neural networks and guiding evaluation, emotion enables learners to monitor progress towards their task-based goals in real time (Immordino-Yang, 2016). This, of course, assumes that the learner is actively and emotionally engaged; they care about understanding how to solve the problem or its relevancy for application to a bigger problem, and are not simply following a protocol or even just intuitively seeing the complete solution.

In education, this is often a question of both good task design and self-regulated learning. Emotion is not linked solely to the task but also to the relationship between person, context and task and how this impacts on associated goals. Furthermore, emotion is key to enabling the learner to move between academic tasks and associated goals. Zull (2006) theoretically presents effective adult learning as involving four major areas of the neocortex through engagement in four stages of a learning cycle: gathering data, reflection, creating and testing. Slow neurotransmitters or 'emotion chemicals' such as adrenaline, dopamine and serotonin, secreted by neurons, generate signalling changes and moderate signal strength to enable engagement at each stage of the learning cycle (Zull, 2006). Understanding the neuroscientific basis of emotion and its connection with the brain's reward systems could help teachers to develop educational goals that feel relevant and motivating to learners (Lucas-Oliva et al., 2022). Moreover, designing educational experiences that enable learners to construct a sense of relevance for themselves can contribute to brain development that makes individuals more adaptive and able to achieve more challenging goals (Immordino-Yang, 2020).

3.2.2 Psychological appraisal perspectives on emotions and goals

At the most fundamental level, emotions can be understood as a way of ensuring our needs can be met in a given situation; a goal that is achieved through the process of appraisal. Lazarus and Folkman's (1984) 'Transactional theory of stress and coping' is valuable for considering, in a more agentic way, the role of the individual in working with challenging emotion. It is based on Lazarus' definition of stress as "a relationship between the person and the environment that is appraised as personally significant and as taxing or exceeding resources for coping" (Folkman, 2013, p1913). This appraisal theory-informed framework foregrounds an individual's continual evaluation process that involves "a primary appraisal of motivational relevance (is what is happening relevant to my goals?) and motivational congruence (if yes, does it foster or hinder the achievement of my goals?)" (Manstead and Fischer, 2001, p3) and a secondary appraisal that involves evaluation of whether an individual has the internal or external resources for coping with the situation. Stress appraisals can include appraisals of threat or appraisals of challenge, "something that may happen that offers the opportunity for mastery or gain as well as some risk of an unwelcome outcome" (Folkman, 2013, p1913). As teachers and learners, we regularly make such appraisals, as we weigh up the risks and benefits of an educational decision.

A particularly interesting and challenging aspect when considering emotion in university learning and teaching is the diversity of emotional experiences within the same context. My

intent is not to seek uniformity of emotion nor recommend ways to achieve this educationally, but rather to better recognise and work with the variety of emotion in inclusive ways. As such, it is important to analyse why this diversity of emotional experience might occur. Appraisal theories can help in this analysis. Appraisal theories state that emotions are aroused by a person's cognitive interpretation, or appraisal, of an event or situation, rather than the event itself. As Frenzel illustrates, “a student would not fear a test *per se*, but test anxiety will be aroused once the student judges the chances of failing the test as sufficiently high, and their potential to avoid this failure as low” (Frenzel et al., 2020, p2). Central to this appraisal is the individual's judgment of their likelihood of goal achievement, which accounts for some diversity of emotional experience.

In addition to this, and fundamental to the ‘Appraisal approach to emotion’ (Manstead and Fischer, 2001) is that, not only do individuals appraise events in different ways, but they also bring different goals to the event, explaining why they experience differing emotions regarding the same event. These different goals are often shaped by differing cultural values (Parkinson, 1996). As individual experiences, appraisals, interpretations and goals may differ, a goal-based approach to theoretical framing allows a common way of considering the diversity of experience, without dismissing the underlying individual detailed differences.

Teachers’ goals are multidimensional including academic, social, and learner behaviour- and administration-related goals (Sutton, 2004). Frenzel et al's. (2020) ‘Reciprocal model on causes and effects of teacher emotions’, foregrounds the influence on teacher emotion of a teacher's appraisal of their success in achieving their teaching-related goals, based on their perception of students' behaviours. Developed for application to school teaching, it posits that teaching goals relate to students' behaviour, including high motivation, high performance, high discipline and high quality teacher-student relationships. Appraisals are based on four dimensions:

1. Goal attainment (goal consistency and conduciveness): Evidenced success at achieving goals and extent to which student behaviour is contributing to this
2. Coping potential: Teacher's perceived capacity to achieve and optimise goals
3. Accountability: Direction of credit or blame for goal outcome
4. Goal importance: Value of achieving goal or avoiding impediment for teacher

Based in my experience, I also judge these to be valuable criteria for understanding university teacher appraisals and emotions. When considering the relationship between motivation, emotion, and self-regulation in schoolteachers, Pekrun (2021) highlights that they are often not able to self-define teaching goals, nor evaluation by which to judge goal

achievement. This is different to some extent in universities, where some teachers can have more freedom to determine goals as part of curriculum and assessment design. Tensions still exist, however, with many university teachers required to facilitate educational goals defined by curricula they would not have designed and being judged by externally imposed evaluation systems. Especially in STEMM, professional body requirements can often have significant influence on design and required outcomes. For many, additionally juggling curriculum development and research-related goals also creates emotional pressure.

3.2.2.1 Emotion and educational goal achievement

Based on appraisal theory, Reinhard Pekrun's 'Control Value Theory (CVT) of Achievement Emotions' (Pekrun and Perry, 2014) is a well-developed and much-cited framework for considering the relationships between emotion and goal attainment in achievement settings. Achievement emotions support attainment of educational goals by focusing attention and cognitive effort on academic tasks and have been demonstrated to positively influence learning performance, grades and other educational outcomes (Harley et al., 2019). This appraisal theory centres on how achievement emotions are generated from our appraisals of our perceived control and the value we place on achieving our goal in a specific context. As Pekrun and Perry (2014) explain "individuals experience specific achievement emotions when they feel in control of, or out of control of, achievement activities and outcomes that are subjectively important to them" (p122). For example, a learner's appraisal and resulting emotion may relate to how much control they perceive themselves to have over an assessment task, including their competence for completing it, or how much personal value they perceive in the topic. Achievement emotions are influenced by valence (pleasant or unpleasant feelings) and physiological activation (activating or deactivating), in line with the influential 'Circumplex Model of Affect' (Russell, 1980), introduced in Chapter 2. Time frame, whether the achievement-related event is in the past (retrospective), present (concurrent) or future (prospective), and the object focus (activity or outcome) of the emotion are also both very significant to shaping the appraisal (Harley et al., 2019). According to CVT, emotion generation begins when we pay attention to a situation or event in our learning environment and appraise it in relation to our relevant goals (Harley, 2020). Goals can be activity or outcome-related. They can also be hedonic, linked to pleasure or enjoyment, instrumental (e.g. to study hard to achieve a high grade, rather than for enjoyment of study), social (e.g. to make friends, to avoid 'loss of face'), or identity-related (to become a competent student, engineer, scientist or doctor) (Parkinson, 2019, Fryer et al., 2016). We apply the key appraisal mechanisms of control and value to our situation in light of our various goals by considering questions like 'Do I have enough control / competency to achieve this goal?' 'It

this valuable for helping me to achieve this goal?’ Different situations will be appraised as offering more or less optimal control and value for achieving our goal, and lead to positively or negatively felt emotions accordingly. In their experience sampling-based study of first year university students, Goetz et al. (2009) demonstrated that students’ positive emotions of enjoyment, pride and contentment were particularly high when they also appraised both control and value of a situation to be high. The relevance of personal value and controllability in making an appraisal explains why a situation may be more stressful to one person than another (Folkman, 2013). This interpersonal variability is often missed by quantitative cohort level studies that report averages. As well as influencing wellbeing (Pekrun, 2019), achievement emotions are important because they positively and negatively impact on learning processes and outcomes. Based on study of 389 university students, Pekrun et al. (2011) found that positive activating emotions (enjoyment, hope, pride) promoted intrinsic and extrinsic motivation, effort, self-regulation and elaboration, whereas negative deactivating emotions (hopelessness, boredom) demonstrated a negative relationship with these aspects and with academic performance. Negative activating emotions (anxiety, anger, shame), whose effect is more complex and nuanced, “correlated negatively with intrinsic motivation, elaboration and self-regulation...[and] correlated positively with students’ extrinsic motivation” (p45).

In addition to achievement emotions, topic emotions, social emotions and epistemic emotions are also relevant and interacting in educational contexts (Pekrun and Linnenbrink-Garcia, 2014). Epistemic emotions – surprise, curiosity, enjoyment, confusion, anxiety, frustration, and boredom – are those experienced as individuals work towards goals of acquiring and generating knowledge (Pekrun et al., 2017). Topic emotions relate to the significance of specific disciplinary content for individuals and social emotions can relate to feelings generated by interactions with others, with whom we share goals or who help and hinder achievement of our goals. Emotions that are inherently socially-based include envy, embarrassment, shame and guilt (Parkinson, 1996). Despite often being used to consider learner emotion at cohort-level, CVT and associated concepts contribute to my theoretical framework by offering a way to think about how each individual’s differing perceptions of value and control, in an educational context, contribute to their emotional experience. It is then interesting to think about how perceptions of control and value impact on emotional influence between individuals. CVT also provides a more nuanced way to think about how negatively valenced emotions are beneficial for development and how learners and teachers make meaning of this.

Teachers also experience emotion based on how much anticipated and actual control they have over a teaching and learning activity or outcome, and how much they value a particular

educational topic, situation or goal. Among schoolteachers, research has consistently shown that forming high quality teacher-student relationships is an important goal leading to strong positive or negative emotions (Frenzel, 2014). Despite the potentially more complex and fragmented nature of teacher-student relationships in HE, they have long been considered important. This may be related to teachers' hedonic goals, for example that relational aspects of teaching feel pleasant, or instrumental goals, such as fostering feelings of trust in order to achieve challenging educational goals. More recently, analytical attention has been given to emotionality within this relationship (Quinlan, 2016, Tormey, 2021) and to the challenges that affective dimensions present for teachers whose goals include to integrate caring into their pedagogy (Walker and Gleaves, 2016). Through their psychoanalytical lens, Gilmore and Anderson (2016) illustrate the difficulty and value in university teachers and students being able to 'hold', or surface for discussion, their difficult emotions, such as meaningful anxiety associated with learning. They illustrate the detriment to learning and relationships when such emotions are not attended to. Together, such work highlights the need for studies that can inform teacher development in this area (Frenzel et al., 2020), so they can identify and address goals relating to emotion in their educational settings. As discussed earlier, this is perhaps even more relevant where STEMM students and teachers may be less familiar with and equipped to deal with emotions involved in collaborative learning.

3.2.2.2 Emotion and beliefs about goal achievement

Whilst appraisal theories are concerned with emotion related to how conducive a situation is to us achieving our goals, self-efficacy theory and attribution theory help to explain the role of emotion in shaping our beliefs about our ability and likelihood to achieve goals. Both offer insight into why learners and teachers experience the pedagogy-related emotions they do and whether this could be influenced, for the benefit of learning and wellbeing. Albert Bandura's (1994) 'Self-efficacy theory' focusses on an individual's belief in their ability to plan for and carry out a specific task in pursuit of a goal. One of the four factors that Bandura identifies as contributing to self-efficacy, in addition to mastery experiences, vicarious learning and social persuasion, is an individual's emotional and physiological state. When we anticipate or experience carrying out a specific goal-related task, this stimulates emotional and physiological reactions. Individuals with high self-efficacy are less likely to experience overwhelming anxiety and interpret their state of affective activation more positively, for example, as energising. Conversely, if a learner has low self-efficacy for passing an exam, for example, they may have a churning stomach, feel anxious and perceive this anxiety as debilitating, and as likely to negatively impacting on their

performance. Barrett (2017) discusses the possibility of individuals influencing this, for example recategorising debilitating anxiety as useful anticipation. Self-efficacy is also relevant for thinking about how teaching staff perceive their preparedness and competency (Ismayilova and Klassen, 2019) and the impact this has on learners' experiences and outcomes, which may not be straightforward (Rodríguez et al., 2014). This can include a teacher's self-efficacy for working with emotions in learning and teaching and is an aspect of practice that my study can contribute to.

Bernard Weiner's (2014) 'Attribution Theory' can offer additional insight into why learners and teachers experience the pedagogy-related emotions they do and whether this could be influenced, for the benefit of learning and wellbeing. Weiner built on the 'Theory of achievement motivation', in which Atkinson (1957) proposed that rather than reward being a material object, reward for an achievement behaviour could be a positive emotion, such as pride. This would be greater if the achievement was success at a difficult task (Weiner, 2014). 'Achievement striving', Atkinson argued, was based on weighing up the likelihood of the emotion to be experienced, so "if anticipated pride from success exceeds the anticipated shame given failure, then a task will be approached" (Weiner, 2014, p354). Weiner's (1985) 'Attribution approach to emotion' posits that emotions are determined by beliefs about causality and three causal properties have been identified; causal locus (whether causes of success or failure are dependent on the individual or other factors, including people), causal stability (whether causes of success or failure are fixed or change over time) and causal control (whether causes of success or failure are controllable by the individual). The beliefs that a person holds about the causal locus, stability or control in that particular situation will impact on their emotion. For example, if a student retrospectively attributes doing poorly in an exam to poor teaching (external locus) and/or lack of choice of questions (control) and believes this is likely to be relevant next time they take an exam (stability) they may feel angry, frustrated and possibly anxious. If a student attributes doing poorly in an exam to their own lack of preparation (internal locus) but thinks they now know how to prepare better (control) for the next time they sit a similar exam (stability), they may feel hopeful. Attribution and emotion have a bidirectional relationship: if a student feels angry post exam they will be more likely to attribute the outcome to something outside their control (Weiner, 2014).

The 'Reciprocal model on causes and effects of teacher emotions' (Frenzel et al., 2020), considered previously (page 39), accounts for teacher self-efficacy beliefs in the *Goal Attainment* and *Coping potential* dimensions. The *Goal attainment* and *Accountability* dimensions take into account attribution theory and to what, or whom, perceived failure or success of teaching goals can be attributed. Attributions can impact the setting of goals, the evaluation of failure or success in achieving goals and the refinement of goals. Attribution

theory is valuable in this theoretical framework because it enables understanding of how individuals retrospectively consider and contextualise their experiences and resulting emotion, including in relation to others, and linked to past and future pedagogic behaviours.

3.2.3 Emotions and divergence in educational goals

This part of the theoretical framework is designed to facilitate critical consideration of emotional experiences and interactions that relate to difficulties in goal achievement. Some less well theorised literature regarding emotion in education, especially when linked to the wellbeing agenda, seems to imply that a desired outcome is to promote positive emotion and reduce negative emotion. There are several reasons why I do not believe that this is possible, nor desirable, as will be elaborated, and I want to explore how participants in the study navigate this. Therefore the following theories that support the interrogation of this are included in the Theoretical Framework.

3.2.3.1 *Emotions and performance goals or learning goals*

‘Achievement goal theory’ contributed considerably to recognition of the relationship between achievement goals in educational settings and emotion (Linnenbrink-Garcia and Barger, 2014) and, I argue, is useful for analysing learners’ and teachers’ diverging and converging goals. Dweck and Leggett (1988) identified the significance of goals in explaining why some individuals, including some of the most academically able learners adopted a maladaptive, helpless approach (avoiding challenge in learning and underperforming in the face of obstacles), rather than exhibiting a mastery orientation (seeking challenge and striving in the face of failure). They elaborated that:

“the goals individuals are pursuing create the framework within which they interpret and react to events. Specifically, in the domain of intellectual achievement, we identified two classes of goals: performance goals (in which individuals are concerned with gaining favourable judgments of their competence) and learning goals (in which individuals are concerned with increasing their competence)” (p256).

Dweck and Leggett (1988) proposed that those oriented towards performance goals tended to hold a theory of their intelligence as being a fixed entity, whereas those pursuing learning (or mastery) goals conceived intelligence as incremental or malleable, and open to improvement. These different goals, they argued, resulted in different emotional responses to failure and setbacks. For example, when experiencing failure, those pursuing performance

goals felt a threat to self-esteem resulting in anxiety and later shame, or defensiveness manifesting in boredom or disdain towards the value of the task. Conversely, those pursuing learning goals perceived failure as a signal that more effort and skill was required, possibly gaining more feelings of satisfaction from that mastery experience. Learning goal pursuers were then likely to gain intrinsic reward in the form of pleasure and pride from the effort of learning (Dweck and Leggett, 1988). However, the relationship between learning goals and positive emotion is also not straightforward. For example, in response to low-effort success, those pursuing performance goals reported feeling proud or relieved, whereas those pursuing learning goals would feel bored or disappointed (ibid). Dweck's (2017) extensive incremental (growth) and entity (fixed) mindset work continues to contribute to understanding relationships between goals, motivation and emotion.

Performance or mastery orientation to learning are often presented as being mutually exclusive and not simultaneously achievable (Dweck and Leggett, 1988), and as a conscious choice on the part of students. It is suggested that as well as setting a performance goal, students may also choose a performance approach (goal to outperform others) or performance avoidance (goal to not be outperformed by others) (Darnon et al., 2010). But is it more complex than this? Darnon et al. (2010) argue that university students pursue multiple goals, rather than 'pure' goals, and that these goals interact. They suggest that students recognise that achievement at university is based on both criterion-based assessment (achieving a disciplinary standard) and a norm-referenced assessment (performing better than, and being selected over others). They reason that mastery goals (developing competency in various skills) may serve performance goals (achieving a degree outcome or prize). Therefore, students who simultaneously pursue multiple goals can demonstrate an adaptive pattern, even though some goals may be performance oriented, because academic performance is accomplished via mastery-related strategies, rather than cheating, disadvantaging others or surface learning (Darnon et al., 2010).

In relation to goal construct in teaching practice, Janssen et al. (2023) recognise the relevance of teachers' multiple goals in educational settings, as well as difficulty in achieving them. "In realistic, complex situations, people often strive for multiple goals simultaneously. When these goals are incompatible, they generally cannot achieve optimal goal realisation. Instead, in such situations, people plan for actions that improve their current situation as much as possible" (Janssen et al., 2023, p4). Butler (2007) first proposed the application of 'Goal achievement theory' as a framework for understanding teachers' differing motivations, suggesting that, like learners, they demonstrate goal orientations, including mastery goals, ability-approach goals, ability-avoidance goals and relational goals. In this study, I build on this to consider, in a university context, how meaning making about multiple and

incompatible goals contributes to social construction of emotion.

3.2.3.2 Discomfort of transformative learning

Jack Mezirow's (2009) 'Transformative learning theory' is valued for the insight it offers into the process of adult and higher learning specifically. Like a number of the perspectives already considered, its foundation is social constructionism and the ways people learn through making meaning of their experiences (Hoggan and Hoggan-Kloubert, 2023). Mezirow defines transformative learning "as the process by which we transform problematic frames of reference (mindsets, habits of mind, meaning perspectives) – sets of assumption and expectation to make them more inclusive, discriminating, open, reflective and emotionally able to change" (Mezirow, 2009, p92).

Mezirow acknowledges that it is likely such transformation will have an emotional impact, that at times feels disorientating and unpleasant, but that will ultimately help the individual develop, including by using emotion to change frames of reference (ibid). My belief is that, as university teachers, our goals should be informed by a higher aim of facilitating this transformative process. For students in a STEM context, we might understand 'transforming frames of reference' as adjusting existing mental schema to accommodate more complex explanations of scientific, technical or medical concepts or processes. It might also relate to adopting new ways of behaving in a lab or clinical settings, becoming aware of different perspectives that challenge their own, or gaining insight that their identity is changing.

A challenge when applying this theory to UGs, such as in this present study where many may still be considered adolescent in biological and psychological terms, is whether they are prepared to set, or even recognise, the goals Mezirow describes. How equipped are UGs for this level of cognitive and emotional disorientation and in what ways should it be introduced and scaffolded? Experience and literature demonstrates that if unfamiliar educational goals are imposed on learners too soon and without sufficient consideration, the consequences can be problematic for students and teachers (Gilmore and Anderson, 2016). I suggest this may be due to unresolved divergence in academic-related goals. If we do not create opportunities for transformative learning, however, how is HE fulfilling its purpose? Perhaps when considering UGs, rather than thinking of transformative learning as a process, it is more helpful to see it as a goal that students are gradually encouraged to own, but initially is likely to feel to them as being imposed and unsupportive, and as teachers we should recognise this. As Quinlan (2016) advises "in creating the conditions for transformative learning, we need to be prepared for and accept the value of students'

emotional discomfort as a natural part of reframing their relationships with themselves and reconsidering their place in the world” (p107).

I include transformative learning theory in my Theoretical Framework as it is a useful way to scaffold critical consideration of what we can expect in terms of transformation in this UG STEM context and the emotional implications of this. For these reasons, it may be more appropriate to apply Mezirow’s concepts to the analysis of transformative learning that university teachers undergo as their perceptions of what teaching and learning means and their role in this are challenged and changed (Ippolito and Pazio, 2019). Their transformed frames of reference are often in response to a significant event, such as facilitating and assessing a module that provokes strong emotional responses. In the context of this study this might involve teachers transforming their teaching goals, or ways of achieving them.

3.2.4 Goals to regulate emotion

The final category of emotion-related goals that will be used to frame this study are those associated with ER. ER can be defined as “the process by which individuals influence which emotions they have, when they have them and how they experience and express these emotions” (Gross, 1998, p275). In reality, it can be difficult to distinguish between emotion generation and ER (Gross and Feldman Barrett, 2011). Goals are central to ER both because the process begins with a person’s goal to influence an emotion, but also because we need to regulate our emotions to achieve our many goals in life (Gross, 2015). An ER goal often involves wanting to upregulate a positive emotion, downregulate a negative emotion or change an unpleasant emotion with negative valence to a positively valenced emotion. This is referred to as a hedonic goal (Harley et al., 2019). For example, a student may choose to study with friends, if they are feeling bored or anxious from studying alone and find working with friends enjoyable. Conversely, when in pursuit of an important longer-term goal, an individual may engage in multistep forecasting, a process that involves predicting future events and emotions (Zaki, 2020). For example, we may accept the discomfort experienced during a period of intensive, difficult and sometimes boring revision if we anticipate, through multistep forecasting, that the long-term outcome will be more positive.

James Gross (1998) developed the ‘Process model of emotion regulation’ to provide conceptual clarity in the burgeoning field of ER research. He later elaborated the ‘Extended process model of emotion regulation’ (Gross, 2015) to reflect the active decision-making in when to start and stop emotional regulation. This active decision-making phase, called

'valuation', involves three stages 1.) identification of the emotion 2.) selection of an appropriate strategy and 3.) implementation of the strategy in a context appropriate way. It acknowledges that some people are not as emotionally aware as others, nor as effective at regulating their emotions. This framework builds on the 'Modal model of emotion' (Gross, 2014) that specifies four steps in emotion generation - Situation, Attention, Appraisal, Response. The 'Process model of emotion regulation' comprises of five families of strategies that can be deployed to target each step of emotion generation (Gross, 2015). The first four, situation selection, situation modification, attentional deployment and cognitive change are classified as preventative, and the final one, response modulation, as responsive (Gross, 1998). Figure 3.1 illustrates concepts from this model that are relevant to this present study, including definitions of each of the five families of ER strategy.

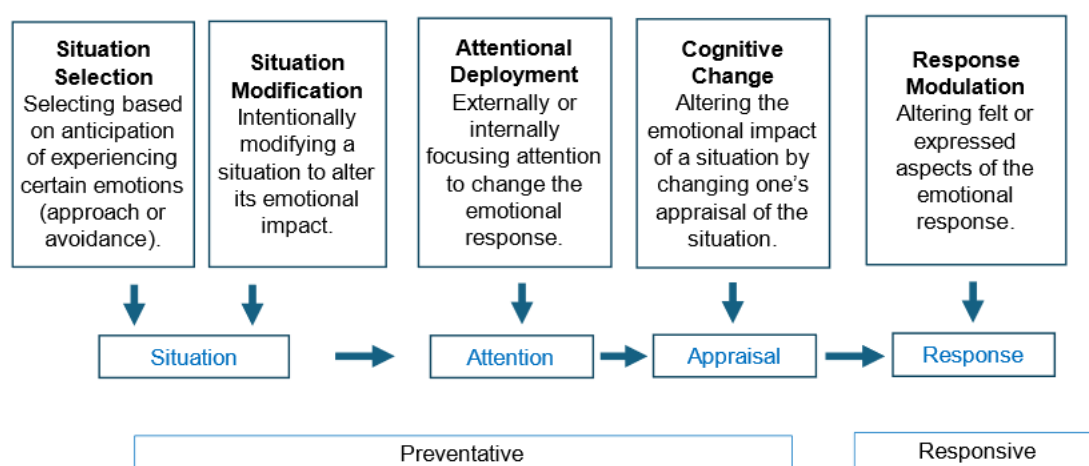


Figure 3.1 Emotion regulation strategies, based on 'Extended process model of emotion regulation' (Gross, 2015)

ER goals can involve changing one's own emotion (intrapersonal ER) or changing someone else's emotion (interpersonal ER) (Zaki, 2020). Gross' model has been applied to educational contexts to consider ER goals and strategies of school teachers (Sutton, 2004), the way that school teachers use hedonic and instrumental goals to regulate emotions (Taxer and Gross 2015) and immigrant academics' use of ER strategies in ongoing processes of adaptation to new university environments (Antoniadou and Quinlan, 2018). It has also been used in combination with Pekrun's CVT to develop an integrated model for understanding, in more nuanced ways, how learner's emotions are regulated in achievement situations (Harley et al., 2019). The nature of the UG population reflected in this study is significant because, as Gross (2015) highlights, the adolescent and early adult phase is an important period for ER that combines new cognitive capabilities, alongside the challenges

of new expectations and heightened emotionality. It will also be valuable to gain insight in relationships between university teachers' ER and their teaching goals and level of integration. Sutton (2004) observes amongst schoolteachers that for those "who believe that regulating their emotions will help them attain specific goals, ER is a sub-goal in attaining a higher goal" (p381).

In this section, I have considered a range of theories linking goals and emotion with learning and teaching, including achievement goals, goals related to success and failure, performance and mastery goals and ER goals. I have developed a framework that supports the critical examination of multidimensional relationships between learners' and teachers' emotions in relation to shared, diverging, multiple and interacting goals. Now I will elaborate the social element of this framework.

3.3 Emotions as social

So far, I have primarily considered how various types of goals can give rise to various kinds of emotions in individuals. However, this study is based on the premise that, although emotions are individually felt, they are socially constructed between people. Barrett (2017) argues that we not only actively construct our own emotion concepts, but we also contribute to the constructions of those we interact with, “[w]e transmit these concepts to each other, wiring each other’s brains for the social world” (Barrett, 2017, p134). Human learning and development involves us using social-emotional experiences to construct a sense of relevance for ourselves and to develop narratives about who we are and what matters to us (Immordino-Yang et al., 2019). James Averill, an early proponent of social constructionism, argued that social beliefs, rules and language inform the way we construct, understand and experience emotion (Averill, 2017). He explained how emotions, such as anger, act as transitory social roles, in situations where norms for behaviour are conflicting, legitimizing as well as restricting our behaviours. Emotions and the appraisals that influence them are very often related to, or provoked by, other people, and regulated in association with others (Parkinson, 1996). Many of the aspects of life that people respond to emotionally are related to socially constructed goals (ibid). This is especially relevant in educational contexts, and more so in collaborative, group-based learning (Lobczowski et al., 2021). This section draws together theories and concepts that explain how people influence each other’s emotion and unpacks why this is relevant for university learning and teaching. It also connects understanding of emotion as goal-based and emotion as social together, strengthening the theoretical framework that supports this thesis.

3.3.1 How do emotions transfer socially?

In order for emotions to be influenced socially and to have a social influence, they need to transfer between people. Empathy is a concept used to explain our ability to perceive and understand the emotions of others and so is a helpful concept for thinking about *how* we are able to perceive and understand the emotions of those around us. Psychological literature broadly agrees that empathy comprises three elements:

- 1) automatic, rapidly occurring *experience sharing* of internal states via emotional contagion (affective empathy)
- 2) conscious, effortful *mentalising* that involves reasoning about how others may feel or be thinking (cognitive empathy) and
- 3) *prosocial motivation* to help others (Zaki and Ochsner, 2016).

3.3.1.1 Emotional contagion

Hatfield et al (1993) proposed 'Primitive emotional contagion' in which a person (target) initially unconsciously mimics another's (source) facial expression, posture and/or vocalisation and then subsequently feels these mimicked aspects as a matching emotional experience, due to afferent feedback. The emotional contagion element of empathy is thought to have an evolutionary purpose. For example, one person transmitting fear can alert others to a threat and in this way it can function as a social learning strategy (Nakahashi and Ohtsuki, 2015). The desire to form an affiliation with others can also make the mimicry aspect of emotional contagion stronger (Parkinson, 2011). It is suggested that individuals vary in their ability to transmit and catch emotions and this may relate to emotional competence and empathy (Verbeke, 1997). Developments in affective science now suggest that although a once influential formulation, primitive emotional contagion (Hatfield et al., 1993) as way to understand how humans influence each other emotionally offers a limited and empirically flawed explanation (Parkinson, 2019, van Kleef and Cote, 2022).

3.3.1.2 Social appraisal

It is helpful here to return to appraisal theory, but this time emphasising a more socially oriented perspective on the development of appraisals linked to emotion. Manstead and Fischer's (2001) 'Social appraisal account of emotional influence' proposes that not only are other people the object of our appraisal, and therefore the source of our emotion, other people's appraisals of a situation also influence our appraisals and emotions. We try to make sense of their appraisals of the situation through their behaviours, thoughts and apparent emotional responses, as well as our understanding of that context. Social appraisal is about making meaning of and responding to *information* about other's emotion (Parkinson, 2019). This can explain why some students may become more worried about an assessment when they perceive that peers are worried, raising the salience and cause for concern. This is especially prevalent when the source's emotion is thought to be credible and reliable, and the target's emotion is malleable, allowing for social influence (Parkinson, 2019). In a university setting this may occur when students perceive each other to be of similar academic ability and at times of transition, unfamiliarity and uncertainty (Bruder et al., 2014). In this way, appraisal is also socially constructed.

3.3.1.3 Emotional contagion and social appraisal

Parkinson's (2011) combined consideration of emotional contagion and social appraisal offers a fuller explanation for how exposure to another's emotion can result in experiencing

similar feelings. This is useful for understanding how such processes occur in university teaching and learning settings and how this differs between people. Drawing on empirical studies, he drew the connection between emotional empathy and mimicking behaviour, noting that “participants with a greater tendency to take on other people’s perspective (those high in cognitive empathy) mimicked behaviour more” (Parkinson, 2011, p429) apparently because they paid closer attention to the other person’s movements. He highlighted a difference between in and out group mimicry, with people more likely to mimic negative emotional expressions by in-group members, yet only positive emotional expressions, such as smiles, of out-group members, as this seems less risky. Further, neuroscientific evidence suggests that emotion contagion may occur through perception rather than physical mimicry and “may depend on neural representations of expressive motor movements rather than motor movements themselves” (Parkinson, 2011, p433). This includes experiments showing that observation of another reacting with disgust can produce similar brain responses in the observer, an effect that may be associated with mirror-neuron areas of the brain (Wicker et al., 2003). More recently, it has been argued that neural ‘mirroring’ is an active rather than passive process, influenced by an individual’s cultural and social context (Immordino-Yang, 2008), rather than the physical existence of mirror neurons (Huberman and Immordino-Yang, 2023). Parkinson concludes that emotion contagion and social appraisal may operate in conjunction “if affect transferred from the emotional meaning of an observed expression is then directed towards a particular object” (Parkinson, 2011, p437). For example, if a student smiles with enjoyment when watching a teacher talking, this may emotionally influence other students who are watching the same teacher because they observe that the target is enjoying the lecture.

It is thought that transfer of emotion is more likely if the people involved have a common goal, shared social identity and relational bond (Parkinson and Simons, 2009). This has implications for perceptions of diversity and the value of cohort building within student cohorts. Furthermore, Ames (2004) claims that when we perceive another person to be behaving ambiguously, in a way that is less familiar, we use strategies such as stereotyping and projection to understand what they are thinking and feeling. “Specifically, when perceivers see themselves as initially more similar to a target, they will rely more heavily on projection and less heavily on stereotyping than when they see themselves as less similar” (Ames, 2004, p341).

3.3.1.4 Relational orientations, convergence and divergence

It is useful, when attempting to understand interpersonal emotional influence in university settings, and factors that contribute to it, to consider the focus of the emotion and how this may align or differ between people. Parkinson (2019) refers to emotions as ‘relational

orientations', that provide information and incentives, helping and motivating people to understand each other and the context. He posits that "[t]he most relevant contextual features concern where the emotion is directed and what it is about" (Parkinson, 2019, p141). In achievement environments, people focus on salient objects or events and develop orientations around them. In the case of a university, it might be knowledge, assessments and/or grades around which they orientate their emotions. Social appraisal occurs when the target processes information about how the source is feeling about specific circumstances, or an object in their shared environment (Parkinson, 2011). For example, a student may observe that a peer is annoyed because they do not think the teaching approach is helpful and this may change that student observer's appraisal of the value of the teaching. This may be partly due to automatic cuing of attention to the teaching approach, that an observer student may not have been paying attention to before (ibid).

Parkinson (2019) defines convergence and divergence as concepts for understanding the interpersonal effects of emotion. When two or more people experience a similar emotion, such as enthusiasm, their emotions converge. Convergence is rarely complete, that is people having identical emotional experiences, and the degree of convergence depends on mutual alignment regarding the context. A teacher may feel disappointed for a student's assessment outcome, but is likely to feel less emotionally aligned than a peer who has also underperformed. Convergence can also happen when two individuals become angry about something for which they blame each other – they "arrive at similar orientations to different objects [each other]" (Parkinson, 2019, p134).

Divergence can be caused by converging as well as conflicting orientations. An example of emotional divergence, as a result of converging orientations, would be a student getting angry about being treated unfairly and a teacher agreeing with them and having a complementary emotional response such as guilt. Emotional divergence based on conflicting orientations can occur in competitive relationships and would include feeling envious about another person's pride in their achievement (Parkinson, 2019). A compassionate emotional response to another's upset or distress is an example of complementary emotional reactions, that van Kleef and Cote (2022) describe as occurring when social motivational implications match, but emotions are different.

3.3.2 Emotion as social information

According to a social functional perspective of emotion, far from being something to avoid or ignore, emotions provide important social information (van Kleef, 2009). In the context of university learning settings, this is also important educational information to guide teachers'

and students' approaches. Despite this, there is little systematic thinking about how we can take notice of, gather and make use of this valuable emotion-related information to inform learner and teacher support and educational decision-making. This study's findings provide evidence of how this information can be used to good effect.

3.3.2.1 What is the value of emotion information?

Here I consider what emotion information tells us, beyond how someone is feeling, and how students, teachers and universities can use this to take action. Emotion can be a useful indicator, with positive emotion signalling that an individual's goals and needs are being addressed, while negative emotion indicates they are not and where attention could be paid (Plass and Kalyuga, 2019). As Folkman (2013) asserts, "Emotions indicate that something is happening that matters to the individual. Emotions often signal what the person plans to do" (p1914). From this perspective, negative emotion can be interpreted in a more nuanced and less problematised way, as an indicator that people really care about what they are doing and their associated goals. More specifically, through greater awareness, emotion-related information can be used by students and teachers to target aspects for attention, not according to a deficit model, but to a goal-orientated development model.

In our university classrooms, emotion-based information may be related to academic goals. Positive emotions can help students understand they are on track to achieve their goals and should sustain, or could reduce, effort whilst negative emotions signal a need for more effort (Boekaerts, 2011), or to seek help (Pekrun et al., 2002). Goals can also be social, as Garner (2010) explains, "emotions are thought to be rooted in relationships because they provide information that is most meaningful in the context of social exchanges" (p297). This can be particularly relevant to peer relationships amongst the late adolescent UG cohorts. Although adolescents, like all age groups, report more positive than negative emotions they are particularly emotionally sensitive to "social feedback and perceived instances of social evaluation" (Somerville, 2018, p352) from desirable peers, as indicated by a greater release of cortisol (Somerville, 2018). Furthermore, "studies suggest that emotionally salient stimuli recruit a stronger amygdala response in adolescents, perhaps reflecting their social communication value during a time of life characterized by social reorientation" (Somerville, 2018, p359).

Participating socially, including in educational settings, relies on us understanding how we fit into a particular social context. As van Kleef and Cote (2022) explain "[t]o successfully navigate social life, people look for information about other's dispositions, goals and intentions. One source of such information is other's emotional expressions" (p636). We

use these emotional expressions to provide information and make inferences about the expresser, the situation and ourselves. For example, we use other's emotional expressions to infer about group functioning, especially in ambiguous situations, about prevailing social norms and how to behave, and about how we are perceived by others and how well we are performing (van Kleef and Cote, 2022). We also use other people's emotions to make appraisals about success and how others evaluate their progress towards goals (ibid).

Finally, explicitly taking notice of emotion as information has a practical application along the lines of distributed cognition. As a collective, we can perceive more because "perceptual and inferential processes are often distributed between different people who register different aspects of what is happening and provide cues to each other about their emergent emotional meaning" (Parkinson, 2019, p181). As discussed, humans are very experienced at unconsciously and consciously identifying how others feel and think, and using this to inform their meaning making and approaches. However, it is also easy to see how misunderstandings regularly occur and how being more intentional in the way we use emotional information in learning and teaching could be beneficial. There is also potential for manipulation with high status group members likely to exert greater emotional influence (Parkinson, 2019).

3.3.2.2 How is emotion information used and what affects this?

Parkinson (2019) clarifies that key to social appraisal is the process of extracting and responding to meaning from information about other people's emotional reaction, as opposed to directly responding to their reaction. He uses Hareli and Hess' (2010) 'Reverse engineering model' to give a possible explanation for how emotion information is used in the social appraisal.

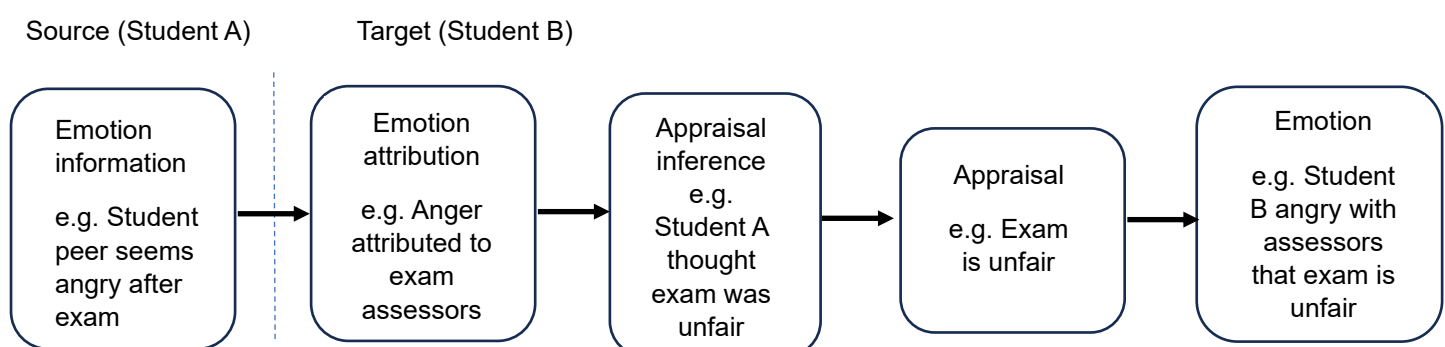


Figure 3.2: The Reverse-engineering process of the social appraisal applied to a student example, developed from Hareli and Hess (2010) and Parkinson (2019)

Hareli and Hess (2010) propose, as illustrated in Figure 3.2, that person B has the ability to use knowledge of person A's observed emotion to figure out *why* they feel that way and from this infer *what* appraisals lead to a specific emotion and *how* person A evaluated an event or situation to create this emotional experience. For example, if a student notices that their peer is angry after an exam they may use their knowledge of anger to conclude that their peer is attributing external blame. This emotion information and attribution may influence person B's appraisal such that they change their interpretation of the event and conclude the exam was unfair and they may also feel angry towards the assessors (based on Parkinson 2019). This process may become even more important when a source's emotion about an object or event may help or hinder a target to achieve their goals.

Although there are strong patterns in the social effects of emotion, there is also much variability between people in terms of the extent to which they are influenced by information in emotional expressions. Van Kleef and Cote (2022) present three moderating factors that are thought to affect this: 1.) *Emotion decoding* which may be influenced by factors like autism and degree of emotional intelligence 2.) *Information processing* which is dependent on an observer's ability, motivation and cognitive resource available to process social information and 3.) *Perceived appropriateness*, in terms of whether the emotion expression is perceived by observers to comply with norms of the social context, regarding showing the right emotion, with the right intensity, and to be considered authentic. This raises the question of how students, especially those from different cultures, know what contextually appropriate emotional expression means, including when their differing cultural understanding misaligns emotional appropriateness to context. For example, anger is considered more appropriate by European-Americans than Asian-Americans (Adam et al., 2010). Further, does a departmental culture in which anger is often expressed mean it becomes perceived as more appropriate?

3.3.3 Socially regulating emotions in educational settings

As mentioned previously, emotion can be regulated by oneself (intrapersonal ER) or by another person (interpersonal ER) (Taxer and Gross, 2018). Zaki's (2020) examination of the interconnections between types of empathy and interpersonal ER can usefully be applied to HE contexts to critically consider how different teachers, and in different situations, respond differentially to student emotion. His ideas can help us to develop empathic responses that are more beneficial for teaching, learning and wellbeing.

Zaki (2020) explains that whereas the *experience sharing* component of empathy involves feeling a target's affect vicariously, *empathic concern* is more proactive and "entails experiencing motivation to improve someone else's wellbeing without necessarily taking on their states" (Zaki, 2020, p519). Zaki (2020) evidences how *empathic concern* is more predictive of generosity, prosocial outcomes and forming close relationships than *experience sharing* and can protect against the burnout amongst caring professionals caused by *experience sharing*. He states that distinct types of empathy produce differing goals, with *experience sharing* more likely to provoke *intrinsic* interpersonal ER. Intrinsic interpersonal ER can be understood as an individual regulating their *own* emotion through social interaction, whereas *extrinsic* interpersonal ER involves a goal to change someone else's emotion. He proposes that the observer's empathic goal will influence the interpersonal ER strategy they adopt. For example, *experience sharing* may lead a teacher to adopt the intrinsic interpersonal ER strategy of situation selection; their goal may be to avoid unpleasant emotion, so they choose to avoid students or educational situations that makes them feel uncomfortable, such as large group interactive teaching or giving constructive criticism on assessed work. On the other hand, *empathic concern* may lead a teacher to adopt the extrinsic interpersonal ER of cognitive change, using examples of past success to persuade a student that they can achieve their academic goal which in turn increases their wellbeing. Taxer and Gross (2018) found that teachers' interpersonal ER strategies often served both intrinsic and extrinsic purposes, regulating both their own and students' emotions.

Interpersonal ER goals often involve upward regulating of pleasant emotions or downward regulating of unpleasant emotions, known as hedonic interpersonal ER. Zaki (2020) is keen to point out this is not always the case, with individuals selecting counter-hedonic goals for themselves and targets. He argues that "[p]eople are emotional pragmatists who pursue feelings not because they are pleasant but because they are useful in a given context" (Zaki, 2020, p521). Due to counter-hedonic motives, such as desire for achievement, a student may deliberately pursue fear in order to make themselves prepare for an important exam and avoid the threat of failing. The mentalising component of empathy enables us to make inferences about emotions and goals, and cooperate by identifying the other person's goals and helping them to achieve these, even when they differ from our own goals. This is known as cooperative interpersonal ER (Zaki, 2020). An example of counter-hedonic cooperative interpersonal ER would involve a teacher adopting an approach so that students experience useful negative emotions, that motivate them to achieve their own goals in the longer term. This more sophisticated form of prosociality is effortful on the part of the observer (Zaki, 2020). Conversely, paternalistic interpersonal ER could involve giving overly positive

feedback and no constructive criticism on an assignment. This is also an example of intrinsic interpersonal ER, as well as extrinsic interpersonal ER, because it can avoid negative emotion in the target and observer.

3.3.4 Emotion socialisation

Emotion socialisation is the term for:

“a dynamic process in which ‘socializing agents’ (Valiente et al., 2020) facilitate development of emotional competence, including ‘community-relevant’ ways of understanding, expressing and regulating emotions (Cekaite and Ekstrom, 2019). They do this through the ways that they react to others’ emotional expressions, through talking about emotional responses and through their own emotional displays (Eisenberg et al., 1998)” (Ippolito and Kingsbury, 2024, p2).

To date, emotion socialisation has been applied to analyse the ways emotional competence is developed between people in families, and pre-school, primary and secondary school contexts. Further, Bolier et al. (2018) and (McCloughen et al., 2020) apply it to critically analyse how medical and nursing students develop the emotional competence to cope in clinical contexts. I suggest that this concept can be novelly applied to understand how student peers and teachers act as socialising agents in STEMM university learning environments. Emotion socialisation can offer a lens for exploring how individuals develop their own and each other’s emotional competency through the process of interacting emotionally in purposefully challenging learning and teaching settings.

This is important because, “[j]ust as students do not arrive at university study with all the appropriate disciplinary knowledge, they also do not necessarily possess the emotional competence to cope and thrive at university” (Ippolito and Kingsbury, 2024, p2) and in professional life beyond. I suggest that they develop community-relevant emotional competence through interacting in a particular social context. Similarly the demands of being a university teacher are continually changing as institutional and educational goals shift, inevitably impacting on teacher’s emotional experiences (Burke, 2017). Hurrelman and Bauer (2018) explain that at each life course stage, humans are confronted with new situations and learn to balance the, often competing, demands of personal individuation and social integration through the process of socialisation. Each individual must learn to cope with the ‘developmental tasks’ involved in this reconciliation process and this can create tension. Socialising agents in education contexts, and especially peers, play an important

role in sharing and offering mutual support for learning to cope with developmental tasks and associated emotion (Hurrelmann and Bauer, 2018).

This section entitled 'Emotion as social' connects theories that seek to explain how people influence each other emotionally, through their social interactions. This includes by emotion spreading via contagion and social appraisal, and through interpersonal ER and emotion socialisation. These processes offer insights into the ways in which we socially construct emotions to make meaning of our environment, including to evaluate our success towards achieving the goals that we socially construct as being valued. As well as these social processes influencing an individual's experienced emotions, they provide information that individuals use to understand how to adapt to their social context and to evaluate the relevancy of their own and each other's goals.

I have developed *Figure 3.3 A theoretical framework for understanding socially constructed emotion in university learning and teaching* to offer a visual expression of the theories and concepts that have been selected and connected in this Theoretical Framework chapter and relationships between them. Having established a theoretical framework, I will now explain how it can be applied to this study.

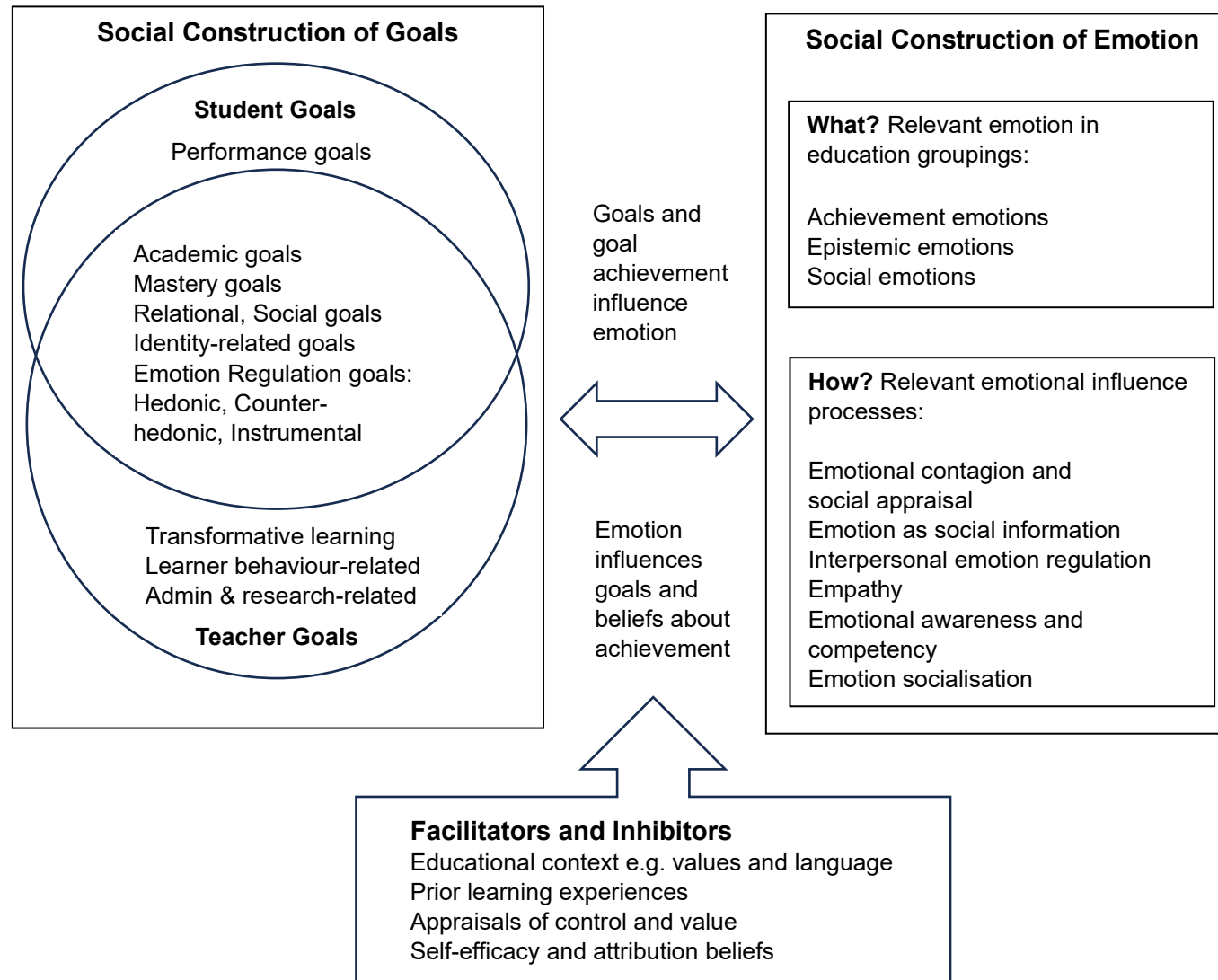


Figure 3.3: A theoretical framework for understanding socially constructed emotion in university learning and teaching

3.4 Application of the theoretical framework

This section considers how the theoretical framework elaborated can be applied to this present study to address the research questions and contribute to understanding of emotional interaction, specifically between STEMM university learners and teachers.

3.4.1 Social construction of goals

As Figure 3.3. illustrates, despite previous lack of comparative consideration between students' and teachers' goal constructs, based on the theories examined, it is evident that there can be a good deal of overlap. Teachers' goals are often defined in relation to how they facilitate the achievement and wellbeing their students, termed student-oriented goals (Butler, 2007). I have attempted to develop a framework that combines both teachers' personal and student-oriented goals, as well as students' goals as it is interesting to examine within my empirical data how these are socially constructed, how they interact, importantly, how they relate to emotion and whether existing separation is unhelpful. The framework brings together a range of goals that I suggest are socially constructed based on cultural values in educational settings and wider societal values and goals. Literature and theories have captured these constructions and further contribute to them. Such a framework enables consideration of which goals are salient to the social construction of emotion in this specific STEMM university context, as identified in the data and, I anticipate, will be more widely applicable. It will also enable reflexive engagement with the data to examine, for example, the validity of my assumptions that performance goals will tend to be held by students and transformative learning goals tend to be held by teachers, factors that contribute to this and implications for curriculum design. It also takes into account the more realistic view that people continually switch their attention and motivation between multiple goals (Fishbach and Ferguson, 2007) and enables consideration of how this influences emotional experience. From my pragmatic position as an educational developer, it provides university teachers with a toolkit of concepts, or foundational principles, at their disposal for better understanding emotion in education and associated literature.

3.4.2 Social construction of emotion

With its multifaceted consideration of how achievement, epistemic and social emotions are constructed between people, this framework enables integrated consideration of the processes by which emotion is socially constructed, the levels of participant awareness about these processes, the emotional competency they demonstrate and how this has

developed. Most of the research underpinning ‘emotion as social information’ is conducted as controlled lab-based experiments “that illuminate causality and pinpoint underlying processes” (van Kleef and Cote, 2022, p650). However, such research cannot capture the way emotion expressions are normally embedded within the noisiness of real-world exchanges, meaning that they need to compete for attention with other information and may be missed (ibid). This variety of explanatory theories is valuable for understanding how humans in learning settings overcome noisiness to capture and use emotional information to understand each other’s goals and associated emotions. The framework also highlights facilitators and inhibitors, derived from the educational and psychological theories considered.

Despite its exploration in other educational settings, emotion socialisation is under-researched in the university context, but I argue that it is highly relevant for various reasons. The active learning approaches increasingly characterising higher education are designed to actively engage learners both cognitively and emotionally (Marshall et al., 2014) and this has implications for learners and teachers that we need to better understand (Riva et al., 2020). Many students relocate away from their primary socializers such as parents, existing peers and schoolteachers for the duration of their studies. University environments are very international, bringing together individuals with diverse and unfamiliar culturally-specific emotional display rules (Mesquita et al., 2016). Because of the relationship between ER and wellbeing (Gross, 2015), it is beneficial that students learn to regulate emotions they experience in learning, as part of that learning. The majority of students are between adolescent and early adult years, a developmental stage when many are highly emotionally reactive (Somerville, 2016) and more aware of other’s emotions (Garner, 2010). There was an interruption to normal emotion socialisation due to the pandemic, with resulting high levels of reported loneliness amongst students (Cibyl, 2022). Furthermore, the importance of emotion socialisation for professional development, especially that of healthcare practitioners, is recognised (Bolier et al., 2018). Taken together, these reasons provide a compelling rationale for researching emotional socialisation in university contexts (Ippolito and Kingsbury, 2024).

By analysing how emotion socialisation processes naturally occur in university classrooms, recommendations can be made for better facilitating contextually-relevant emotional competence development. As Mark Brackett, Director of Yale Center for Emotional Intelligence, recognises, it is difficult to systematically integrate emotional learning into HE due to lack of systematic approaches, student population sizes, nature of student and staff relationships and perceived lack of value (Brackett, 2019). This is also important in light of concerns that approaches for ‘embedding wellbeing the curriculum’ (Houghton and

Anderson, 2017) and so-called 'therapeutic education', are not the role of academics, waste curriculum time and risk positioning all students as vulnerable (Ecclestone and Hayes, 2019). Instead, I aim to illustrate an alternative approach that integrates navigating the emotion experiences inherent in challenging STEMM learning into scientific and technical learning processes themselves. Through exploring this possibility and the barriers, I also hope to offer ways to broaden conceptions of academic goals and educational gain in university teaching and learning.

3.5 Chapter conclusion

Together 'Emotions as goal-based' and 'Emotions as social' creates a theoretically coherent and innovative framework through which to examine my empirical data and answer my research questions. Despite the evident relevance of these concepts to the highly social, goal-based environments that characterise university learning and teaching, this social-functional perspective on emotion has not been used to analyse university learner and teacher experiences. I believe that it will give valuable insights to enable more nuanced and critical understanding of the role of emotion in STEMM university teaching and learning that can be practically applied to inform curriculum design and engagement. In Chapters Five to Eight, I apply this framework to make meaning of how STEMM students and teachers socially construct emotion and identify empirically- and theoretically-informed, yet pragmatic, recommendations for educational development.

4. Methodology

4.1 Chapter introduction

Having reviewed the relevant literature and established the thesis' theoretical framing, in this chapter I describe and justify my methodological choices. I first give an overview of approaches to researching emotion, including specifically in education, to illustrate how this has informed my research design. Next, I set out the philosophical positioning of the study, and my positionality. Then, I describe in detail the methods for sampling, data collection and ethical considerations. Finally, I explain the approach taken to ensure rigorous data analysis.

4.2 Research approach

4.2.1 An overview of approaches to researching emotion in education

Researching emotion in postsecondary teaching and learning has been described as unruly (Cox, 2022), owing to the differences in opinion in defining and conceptualising emotion and the many fields contributing theoretically and methodologically (Zembylas, 2007). Many of these theories and associated empirical studies have been considered in the Literature Review and Theoretical Framework Chapters.

Much of the research on emotion in education is within the Psychology discipline and is quantitative in nature. Social psychologists Burr and Dick (2017) critically consider the reliance on quantitative methods for researching social phenomena and attribute it to “a value system whereby quantitative methods are seen as more likely to produce ‘hard facts’, data that can objectively, reliably and accurately inform us about the nature of the social world” (p69). The empirical data collected by psychologists to measure emotion broadly comprises introspective self-observation and external observation (Reisenzein et al., 2014).

Research of educationally relevant emotions has a long tradition of using self-report methods, beginning with research into test anxiety in the 1930s (Pekrun and Bühner, 2014). Proponents claim that an advantage of self-report is that it can assess all components of emotion: the affective, cognitive, motivational, physiological and behavioural-expressive (ibid). It also evidences relationships between these components and learning processes, as Pekrun (2020) asserts, “self-report is indispensable to capture the psychological processes driving human learning, such as learners’ emotions, motivation, strategy use, and metacognition... [as it] shows convergent and predictive validity” (p185). Furthermore, self-

report approaches recognise that participants are best placed to interpret a highly subjective phenomena such as their own situated emotions (Turner and Trucano, 2014). Indeed, “[a] science that disavows the connection between emotion and subjective experience would, in effect, abandon the goal of explaining the phenomena that people actually deemed to be emotional in nature” (Keltner et al., 2019, p2). Self-report is often conducted using validated emotion rating scales (Pekrun and Bühner, 2014) such as the Achievement Emotions Questionnaire (Pekrun et al., 2011), Epistemic Emotions Scale (Pekrun et al., 2017) and Teacher Emotions Scale (Frenzel et al., 2016) that produce quantitative data. In education-focussed research, self-report tools are ideally used in the setting where the learning processes under investigation occur naturally (Pekrun, 2019). Pekrun (2020) identifies approaches to strengthen power in self-report, including using alternatives to closed-response quantitative methodologies, analysing within-person data and considering how respondent emotions impact in self-reporting, each of which I consider in this present study.

Despite the value of laboratory studies in emotion research, “to fully capture the richness and complexity of affective phenomena, we must also study emotions in the muddiness of daily life” (Kuppens et al. 2022, p505). Accordingly, emotion researchers are increasingly collecting ecologically valid data via Experience Sampling Methods (ESM) and Ecological Momentary Assessment (EMA). These facilitate the collection of self-report data, often via smartphones, that attempts to capture participants’ emotions, cognitions and/or behaviour as they go about their day, in their normal environment, at or close to the time they carry out that behaviour (Larson and Csikszentmihalyi, 2014). Study designs usually involve an experimenter-initiated scheme that defines the regular intervals between data collection points. Challenges include how to capture the nuances that contribute to emotional relevance in that specific context (Kuppens et al., 2022).

External observation includes assessment of behaviour and psychophysiological and neurophysiological measurements (Reisenzein et al., 2014). Again, traditionally much of this research has been conducted in psychology laboratory settings, where manipulation methods are used to elicit specific emotion, aspects of interest can be isolated and, as far as possible, confounding factors can be controlled for (Parkinson, 2019). Laboratory-based research is limited as far as giving insight into the dynamics of how humans influence each other’s emotion in real-world contexts, and specifically in educational settings (Frenzel et al., 2021). It fails to capture how, in the real world, contextual knowledge is key to how people make emotional inferences about other’s observed behaviour. As Reisenzein et al., (2014) articulate, “emotion inference in everyday life seems to proceed as follows: one observes that another person reacts in a particular way to a particular event, and one then uses one’s implicit knowledge about the connections between eliciting events, mental states, and

diverse behavioural indicators of mental states to infer that the other person probably experiences a particular emotion” (p582). Deliberate, real-world observational research includes video-based studies such as Järvenoja, Näykki & Törmänen’s (2019) investigation of university student groups collaborating over 87 hours of maths classes.

As discussed, neuroscience is now contributing significantly to research on emotion. Research tools and approaches used in the neuroscientific study of emotion include Functional Magnetic Resonance Imaging (fMRI), Magnetoencephalography (MEG) and Electroencephalography (EEG) and, as these technologies are lab-based, they do not yet offer a useful way to observe emotional dimensions of learning in classroom settings (Immordino-Yang and Christodoulou, 2014). The early use of Electrodermal Activity (EDA) to measure emotion in the context of learning, via skin conductance, and insights this offers into relationships between physiological arousal and learning outcomes is summarised in Horvers et al.’s (2021) review.

A key consideration for emotion in education researchers is whether they are capturing more situation-specific ‘emotions as states’ (temporary experiences) or more person-specific, ‘emotions as traits’ (dispositions leading to more habitual experiencing of certain emotions) (Bieg et al., 2022). Despite questionnaires being cited as a way to collect data on trait emotions (Frenzel, et al., 2021), Pekrun et al. (2005) explain that the Achievement Emotion Questionnaire can be used to collect trait or state emotion data, depending on the instructions given to students. I am aware from experience, that even then the researcher cannot be sure whether responses were given with an ‘emotion as state’ or ‘emotion as trait’ construct in respondents’ minds. Furthermore, when considering the collection of data in ecologically valid settings, such as classrooms, Frenzel et al. (2021) question whether the distinction between state and trait needs to be strictly observed, and that the relationship between the two may be of particular interest. They note, of the rare studies that assess reciprocal emotional connections between teachers’ emotions and their students’ outcomes, the distinction may not be helpful given the way that trait and state emotions seem to interact and influence each other in classroom contexts.

In this chapter, I illustrate how understanding of the considerations, strengths and limitations of approaches to researching emotion in education, outlined above, have informed this study.

4.2.2 Philosophical paradigm

My research has a philosophical orientation that combines two research paradigms: social constructionism and pragmatism. Savin-Baden and Howell Major (2013) support this

'blended philosophies orientation', suggesting that the adoption of attributes from two paradigms offers a researcher additional freedom to more appropriately address their research problem and context.

4.2.2.1 Social constructionism

Social constructionism centres on individuals constructing social meaning and shared realities through interaction (Savin-Baden and Howell Major, 2013). This is an appropriate approach for a study on emotion because "[c]onstructionists believe that hidden or private phenomena such as emotions gain their meaning through social settings and practice, and are therefore socially constructed" (ibid, , p62). Given my theoretical framing emphasises emotion as being socially constructed (Barrett, 2017) and my interest in how student peers and teachers co-construct emotions associated with learning and teaching, the study is conceptually and methodologically well-aligned (Zembylas, 2007). I strongly believe that university student learning is best supported by teaching teams who talk and negotiate meaning and have intentionally facilitated this social constructionist process through my research methods, also involving myself, as researcher, in this dialogue and negotiation (Savin-Baden and Howell Major, 2013).

Burr and Dick (2017) highlight the value and challenge that a social constructionist orientation, and specifically "the position that there is no definitive "truth" to the nature of the world or of people" (p63) creates in Social Psychology, which inherited assumptions about the nature of knowledge and research rigor from the natural sciences. Even in the relatively interpretivist discipline of Education this reticence of social constructionists to pin things down can be problematic. After all, Education is an applied discipline, largely interested in identifying and addressing challenges that impact on learning and teaching. STEMM Education is even more problem and solution-focussed, with a natural tendency toward quantitative and positivist approaches and expectation of objectivity. I argue that, in order to better understand why students and teachers feel the ways they do about learning and teaching, we need to listen carefully to how they construct meaning in their language, and a social constructionist approach supports this. However, we also need to be able to identify tangible issues and make concrete recommendations that resonate with the experiences of STEMM educators and take them beyond current understanding and practice. This is where pragmatism is valuable as a research paradigm.

4.2.2.2 Pragmatism

Pragmatism as a research paradigm is orientated towards addressing real-world problems and is well-aligned with practical-minded, action-focussed research (Kaushik and Walsh, 2019). Developed by Charles Stuart Peirce, William James and John Dewey, pragmatism as a philosophy and research approach has a long history in both Psychology and Education disciplines. Priestley and Mazzoli-Smith (2023) advocate the use of a pragmatist methodology for working with data related to students' subjective accounts of their emotional responses to university contexts which, they argue, are based on understandings shaped by power dynamics. Pragmatist beliefs include that knowledge is always partial, and emerges in context and through experience, and for these reasons is a valuable approach for truly understanding the complexities of emotional wellbeing in universities (Hughes and Priestley, 2024). For pragmatists, the research question is central to the study and an eclectic variety of data collection methods that allow the researcher to answer their question are permitted (Savin-Baden and Howell Major, 2013). As an insider at the institution at which the study is based, I have access to range of contextual data to help me explore and make sense of issues and identify recommendations. Importantly, pragmatism also acknowledges the complexity and limitations of individuals recalling and making sense of their experiences. As Kaushik & Walsh (2019) explain, "some versions of those social constructions match individuals' experiences more than others" (p3), and the recall of emotional events is highly vulnerable to bias (Evans, 2001).

Whilst understanding derived from an interpretivist approach seeks appreciation for being interesting, a pragmatist approach aims to construct knowledge that is valued for being useful (Goldkuhl, 2012). As a practical-minded, researcher-educational developer, I aim to contribute to better connecting educational research with HE practices. This is based on concerns that, despite intentions towards more evidence-informed educational practice, HE practitioners and leaders still tend to base decision-making on personal experiences rather than educational research (Newton et al., 2020). Furthermore, where decisions are more evidence-based, for example, student evaluation of teaching quality, adopting a more pragmatism-oriented approach would lead to more critical consideration of the validity of this as a single source of data, with a preference for triangulating it with additional stakeholder perspectives (ibid). Taking a pragmatic orientation also enables me to demonstrate to HE practitioners that personal experience can be a valid data source, but that it needs to be interpreted through a theoretical lens such as the one elaborated and applied in this study. Finally, given that a limitation my study aimed to address was single source bias, with most studies only reporting on teacher and/or student emotional experiences from teacher's

perspective or student perspective (Frenzel et al., 2021), it is important that pragmatism allows research questions to be addressed by multiple sources (Allemang et al., 2022).

Social constructionism and pragmatism are complementary in that both see interaction as being central to the purposes of research. From a social constructionism perspective, knowledge is seen as being constructed through interaction outcomes (Savin-Baden and Howell Major, 2013). Epistemologically and ontologically speaking, pragmatism proposes that knowledge and reality are based on individuals' diverse experiences, beliefs and practices and are socially constructed. Furthermore, pragmatism recognises that individuals' different experiences inform different worldviews, but some overlap of experiences can result in shared beliefs (Kaushik and Walsh, 2019).

4.2.3 Positionality

I am aware that my positionality, including as an educational developer, experienced university teacher, student, woman and mother, has guided the whole research process from selecting the focus, through gathering and analysing data, to reporting key findings. I have attempted to maintain reflexivity throughout, including through wide and critical engagement with scholarship, discussion and reflection, but acknowledge that my direction and interpretations are profoundly influenced by my experiences and perspectives. Ultimately, I decide whether something is of value or interest and, of course, my emotions - what surprises me, disappoints me, confuses me - will attract my attention and guide my interpretation. As an educational developer, the idea of constructing meaning through interaction and applying this to improve my own and other's practice is very instinctive and appealing. I have consciously guarded against my natural tendency to want to quickly use findings to educationally develop improved approaches, rather than engage fully in the research. Despite this, I have been using conceptual connections and data, and applying new understandings, to inform teaching and educational development work which affords me invaluable opportunity to try out the utility of new ideas in an authentic context, and believe this has enriched my study. As a university teacher of 23 years, with experience of considering my learners' emotions, and talking to university teachers about their own and their students' emotions, I am biased by my belief that this is aspect of interest around which awareness can and should be improved. I am also an advocate of collaborative learning approaches and feel positive about their potential for building connection between student peers and teachers that supports both learning and feelings of wellbeing. However, my research is also guided by concern that if university teachers and students are not sufficiently equipped to interact in active learning classrooms and to manage the emotions

constructed therein, there is potential for negative impact on learning and wellbeing. The advantages associated with my positionality is that as an institutional insider I have a cross-university view and access, yet I inhabit a non-STEMM disciplinary location, and this gives me a useful outsider perspective. I also have an ability to readily implement the outcomes of my research which is highly motivating.

4.3 Methods

4.3.1 Study context

This is a qualitative, single-site study set in a research-intensive university specialising in Science, Technology, Engineering, Maths and Medicine (STEMM) in the UK. The research focuses on seven UG modules from across the Faculty of Natural Sciences (FoNS), Faculty of Engineering (FoE) and Faculty of Medicine (FoM). See Table 4.1 for details. These modules were purposefully selected through reputational case sampling (Savin-Baden and Howell Major, 2013) on the basis that knowledgeable experts identified them as valuable and interesting examples of collaborative, active learning. This is directly related to a recent institution-wide curriculum change process (Kandiko Howson and Kingsbury, 2022) that resulted in increased collaborative learning approaches. These are potentially challenging for students and teachers due to the socioemotional interaction involved (Lobczowski et al., 2021). I have taken a case study research approach “that examines the relationship between people and structures, in which they work, live and learn; it acknowledges that the dynamics of the interaction must be the starting point for research” (Savin Baden and Howell Major, 2013, p168). I believe that this is the best way to reflect the educational context that is required to understand the dynamics of emotional interaction and social construction. The case study is a STEMM university, with seven case studies of specific UG modules within it. The relevant characteristics that bind the cases in this case study research (Yin, 2018) are that they are all UG modules in STEMM subjects at Imperial College, that involve substantial collaborative, active learning, resulting from a university-wide curriculum redesign that took place between 2017 and 2020.

Discipline	Year group	Teaching and Learning Approach
Chemistry	Year 1	Students work in wet lab-based small groups to develop skills for practical chemistry, including techniques in chemical synthesis, computer modelling, data analysis

Faculty of Natural Sciences		and beginning to plan their own experiments. This is prefaced by 'Chemical Kitchen' that introduces students to a creative mindset and fundamental lab skills through cooking.
Electrical and Electronic Engineering Faculty of Engineering	Year 1	Group-based engineering design project over final summer term, involving students building robotic moon rovers and culminating in a demonstration.
Life Sciences Faculty of Natural Sciences	Year 2	Students work in consistent small groups, using a Team-based Learning (TBL) approach to learn statistics and programming. This involves pre-work, individual tests, team tests with immediate feedback and application activities.
Mechanical Engineering Faculty of Engineering	Year 2	Intensive week-long, team-based project based on an engineering design consultancy firm simulation. Activities involve students experiencing the whole design process, applying fundamental knowledge and facing uncertainty created by an authentic brief.
Medicine Faculty of Medicine	Year 1	Students work in consistent small groups using a combined Case-based Learning (CBL) and Team-based Learning (TBL) approach. This involves pre-work, individual tests, team tests with immediate feedback and application activities. Cases are designed to develop clinical reasoning skills, underpinned by scientific knowledge and evidence-based research.
Medicine Faculty of Medicine	Year 1	Students work in consistent small groups, facilitated by clinical tutors, to address challenges relating to behaviours and values within the medical profession. This involves discussion about scenarios that raise ethical dilemmas and prompt consideration of how to work with uncertainty and differing perspectives.

Physics Faculty of Natural Sciences	Year 1	Students work in consistent small groups in bi-weekly seminars, linked to a lecture series, to solve problems designed to require collaborative thinking. The session in which student data was collected specifically involved students developing concept maps to aid collaborative recall and connect physics concepts.
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Table 4.1: Details of seven UG modules comprising the case study

4.3.2 Data collection

4.3.2.1 Data collection overview

The data collected and analysed for this study is qualitative in nature and aims to model methods and give insights that much quantitative research of emotion in education misses, such as the factors behind *why* people feel the way they do and *how* they make meaning of their own and others' emotions. This study makes use of a self-report approach, as I judge participants to be well positioned to interpret a highly subjective phenomena such as their own situated emotions (Turner and Trucano, 2014). Criticisms of self-report include that validity may be compromised as a result of participants deceiving themselves about how they feel, or giving socially desirable responses, relating to how they think they should feel (Frenzel et al., 2021). This is possible, but as this study does not seek to demonstrate that certain conditions or factors lead to specific emotions, but rather examine how participants make meaning of emotion in educational contexts, including what is socially desirable, I judge the advantages to outweigh the disadvantages. This study also takes advantage of the human ability to observe behaviour and infer about other's emotions in daily life, based on their contextual knowledge (Reisenzein et al., 2014). It involves students and teachers as co-participants in this process. When exploring university students' experiences of learning, I have always been drawn towards triangulating perspectives from students and teachers (Ippolito, 2007, Horsburgh and Ippolito, 2018). Although this is complex, I feel that it is valuable to be able to understand the case study context from both 'sides'. From an educational development perspective, it also enables me to move between stakeholders to some extent, sharing anonymised data to facilitate dialogue that may not otherwise happen (Smith, 2006).

Data was collected between April 2020 and February 2023 using the following three step process (indicated in Figure 4.1). First, 90-minute online focus group interviews were conducted with each of the seven trios of teachers to explore their awareness of the role of emotion in their module's learning and teaching and their approaches to working with emotion. Second, at the end of a teaching session, students from each of these seven

modules were invited to complete a voluntary free-text, in-situ anonymous questionnaire. Third, anonymous student data corresponding to each module was presented back to members of the module's teaching team for consideration and a 60-minute interview was held to explore meaning in the student data.

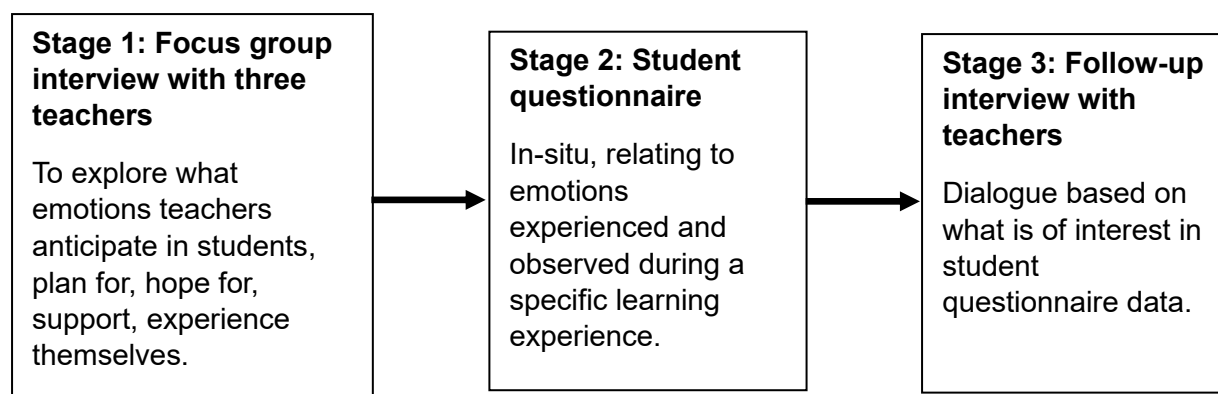


Figure 4.1: Overview of data collection process

4.3.2.2 Focus group interviews with teachers (Stage 1)

I chose to conduct focus group interviews, comprising three teachers because, alongside gathering their perspectives on the topic, I was interested in the way that teachers interact to construct understanding about how to work with emotions in learning and teaching. Savin-Baden and Howell Major (2013) make an important distinction between group interviews, focus group interviews and focus groups. The focus group interview “is a form of group interview but the primary difference between it and other group interviews is that interaction of group members is encouraged...[and] can allow the researcher to view social processes in action” (Savin-Baden and Howell Major, 2013, p375). I did not choose individual interviews, even though this potentially sensitive topic may seem suited to a private method. This was because, as well as wanting to capture teacher interaction, I judged that being in a group that would allow thinking time about previously unarticulated ideas about emotion, whilst other participants were speaking. It was also possible that, through the focus group interviews, teaching teams who had a level of trust and common 'enterprise' in their shared teaching, could co-create and co-articulate a shared understanding that in many ways represented them as a teaching unit.

An often-cited advantage of group interviews relates to efficiency, but this was not my driver. Mindful of taking busy teachers' time, I was keen that there was benefit in it for them, such as being able to hear each other's previously unshared views. This seemed like a useful, professionally developmental activity and a way of giving something back in return for participants' time. I hoped this would lead to enhanced understanding about how others feel

and the potential for collaboration and mutually beneficial support. Given that emotion in STEMM education is a less explicitly considered and potentially controversial aspect of university teaching, I also wanted to gain insight into teaching team interactions and negotiations around how best to support learning and wellbeing. Therefore, my approach was guided by Cohen et al.'s (2018) advice that with group interviews, "[i]t is also possible to detect how the participants support, influence, complement, agree and disagree with each other and the relationships between them" (p527). I was also alert to the disadvantages of group interviews which include one participant dominating, participants being unwilling to be honest in front of each other or 'group think', rather than individual views emerging (Cohen et al., 2018).

4.3.2.3 Conducting focus group interviews

Teachers were recruited by emailing them directly as a teaching team or as the module lead who, having accepted my emailed invitation, suggested inviting appropriate teaching team colleagues, using a snowballing sampling method (Parker et al., 2019). In advance of the interviews, I asked the participants to share with me documentation of their choosing that would give me insight into the module and allow me to contextualise their responses.

Documents included a combination of module specifications, student guides and evaluation data. I read and made notes on these to inform my preparation and referred back to them during analysis and interpretation stages. In these semi-structured focus group interviews, I first asked questions about the emotions that teaching staff identified amongst their students and the possible reasons for these. I then progressed to questions that explored teachers' approach to working with emotion in learning, including how teaching on this module made teachers feel (see Figure 4.1 for indicative Teacher focus group interview schedule). All seven focus group interviews were conducted on MS Teams, due to the Covid19 pandemic, and lasted between 85 and 90 minutes. They were video and audio-recorded on Microsoft Teams, as well as on a digital recorder.

Teacher focus group interview schedule

1. How does learning in this module make students feel?
2. How do you know?
3. In what ways do you take these emotions into account when planning / when facilitating / when giving feedback?
4. Is this different in the newer, active learning contexts?
5. How does teaching this module make you feel? Please give a reason for your response. (Give option to speak about how teachers in general feel, rather than describing their own emotions).
6. Do you think that you reveal your emotions in the classroom? If so, when and why? If not, why not? (What conditions are in place?)

Activities using PowerPoint slides:

Activity 1 Identify two emotions from the list provided that you observe in students and aspects of the module you think contribute to each emotion (Each teacher responds in turn).

Anxiety	Frustration	Pride
Boredom	Hope	Relief
Confusion	Hopelessness	Enjoyment
Curiosity	Anger	

Activity 2 Identify whether you think the emotions on the right have positive or negative valence (make individuals feel pleasant or unpleasant) and whether they have a motivation-related activating or deactivating effect on learning. (All three participants gave suggestions and one then dragged the emotion to the agreed position on the 2x2 grid. I was as interested in the reasons given for the position of each emotion, as the actual position.)

Activation of Learning		Emotional Valence			
		Positive (Pleasant)	Negative (Unpleasant)		
	Activating			Anxiety	Frustration
	Deactivating			Boredom	Hope
				Confusion	Hopelessness
				Curiosity	Pride
				Enjoyment	Relief

Activity developed from Pekrun & Perry (2014) and Pekrun et al. (2017).

7. Ideally how do you want students to feel?
8. What can you currently do to try to achieve this? What constrains you?
9. What do you think is the relationship between how your learners feel about their learning and their general wellbeing?
10. What do you think is the role of teaching staff in considering emotion and helping students to regulate their emotions?
11. Is there anything else you would like to add?

Figure 4.2: Teacher focus group interview schedule

As Figure 4.2 indicates, part way through the interview I invited participants to complete two activities that involved working with Pekrun's (2006) achievement emotions and Pekrun et al.'s, (2017) epistemic emotions. Activity two was informed by the cognitive-motivational model of emotion effects, a component of Control-Value theory that is interested in understanding the effects of emotions on achievement-related motivation and behaviour (Pekrun and Perry, 2014). As Pekrun and Perry explain:

"The impact of emotions on achievement is thought to be mediated by a number of cognitive and motivational mechanisms. All of these

mechanisms derive from the basic functions of emotions for adaptive behavior. To adapt to environmental demands and personal goals, emotions help to draw attention to the object of emotion, instigate motivation to deal with the object in appropriate ways, and trigger cognitive modes of processing information that support adaptive behaviour (Pekrun and Perry, 2014, p132).

Participating teachers used the grid to support their consideration how they perceived their students' emotions to impact on motivation or behaviour to respond to and achieve in an aspect of their learning. This process was completed by all seven of the teacher trios, and video and audio recorded on MTeams. The PowerPoint slide created by each trio was saved for consideration alongside their focus group interview transcript.

4.3.2.4 Reflexivity in teacher focus group interviews

My focus group interview design illustrates how I deployed pragmatic and social constructionist-informed approaches, to generate and gather what I believe is valid and useful data. I deliberately began by asking open questions that enabled teachers to use their own natural language and terms to describe their learners' and their own emotions. In this way, together they socially constructed a narrative about how they perceived the emotional climate in their classroom. The categorisation-based activities had a more essentialist basis, as participants were asked to identify prototypical expressions of emotion (Parkinson, 2019) based on their observations and inferences, and label them with a limited number of prescribed emotion labels. Later questions involved teachers socially constructing a narrative that involved surfacing and sharing tacit understanding of how university teachers do and can work with emotion in learning. My justification for this mixed approach is that, from experience, I believe this more authentically reflects how we make sense of emotion in real-time contexts of teaching practice. As teachers, we intuitively learn to recognise and respond to a dynamic variety of emotions in the course of teaching and supporting learning. To an extent, we have to make assumptions based on our lay observations and understandings of emotion. This includes using a limited range of emotion labels for our own comprehension and communication with others, for the sake of pragmatism. However, I also wanted to explore how, through talking more deliberately about emotion in learning and teaching, we can understand how emotions contribute to meaning making and are influenced by meaning making. By introducing these emotion theories and categorisations to teachers, I will have influenced their understanding and contributed to their social constructions. For example, Activity 2's 2x2 grid introduced a prescribed model that opened up a new way of conceiving and socially constructing emotion in learning, including challenging some lay preconceptions, as anticipated. This appeared to surface

and challenge tacit understandings and deepen individual and collective reflections, scaffolding social construction of new knowledge and enabling data capture of this. It also enabled me to see what was possible in terms of developing teachers' tacit awareness and I have acknowledged this social influence, including by me as the researcher, in my analysis.

As anticipated, because I identify and am identified as a teacher at Imperial this enabled a dialogic quality to the interviews with teaching staff. It has also required reflexivity to avoid leading or influencing participants unduly. I anticipated and accept that my presence influenced the social construction process, including what participants were willing to share. I also believe that the dynamic we created together contributed to the richness of the data. I listened to and transcribed interviews promptly and reflected on the nature of my comments and interjections, aiming to reduce unhelpful interruptions at subsequent interviews, but to ensure we finished within 90 minutes. I also recognise the role of my own emotions and how these and my goals, what I value and my sense of control, have influenced all stages of my research. I endeavoured to take into account any perceived power imbalance at all stages. See ethics section for a fuller consideration of this.

4.3.2.5 Student questionnaires (Stage 2)

I chose to collect data from students using questionnaires and for this purpose designed what Braun et al. (2020) refer to as a 'fully qualitative survey'. I chose this approach, rather than using validated scales, as, from experience, I felt scales would not allow me to understand *why* students feel the way they do or to gain insight into their social constructions of emotional experiences. The rationale for choosing questionnaires was manifold. First, to increase ecological validity (Kuppens et al., 2022), I wanted to collect in-situ data about emotional experiences as close to the relevant learning experience as possible and administering online questionnaires towards the end of a relevant session facilitated this. This was also anticipated to increase the likelihood of students describing current appraisals rather than post-event reappraisals (Hartikainen et al., 2022). Second, a questionnaire facilitated me collecting data from a larger number of students, in order to hear a diversity of perspectives (Clarke and Braun, 2017, Clarke and Braun, 2013), than would be manageable for a single researcher through focus groups or interviews. Third, I also recognised from experience that students' recruitment to focus groups or interviews, that involved significant effort and time on their part, may be difficult, especially during and following the Covid19 pandemic when data gathering occurred. Fourth, focus groups and interviews may also be more prone to selectively bias, with those students choosing to attend being those who felt more positive about their experiences, or even strongly negative, offering less diversity of perspectives. Fifth, given the highly personal and potentially sensitive focus on emotions in

learning, I concluded that offering the protection of anonymity would be preferable (Braun et al., 2020). This anonymity also reduced the perceived power differential, although I acknowledge that, as an Imperial staff member, I could only mitigate against, and not completely avoid this. The main risks involved in using questionnaires were the response rate and quality of response, especially to questions that asked students to consider other people's emotions. To address this, I piloted and discussed the questions with colleagues. Finally, questionnaires administered using Microsoft Forms produced an Excel spreadsheet of students' survey data for each module-based case study. This enabled me to share the anonymised student data with the relevant teachers in a format that was more familiar and easier for them to consider than interview transcripts.

4.3.2.6 Student questionnaire design

As an alternative to closed-response quantitative methodologies, and as advocated by Pekrun (2020), the questionnaire comprised open-ended questions. I limited the survey to nine questions, ensured questions were open, short and as unambiguous as possible, and clustered questions according to similar aspects (Clarke and Braun, 2013). Each question was conceptually underpinned by emotion theory. For example, Questions 1 – 3 (Figure 4.3), were designed to elicit from students an experience of emotion relating to a specific episode, with associated appraisals and attributions that contributed to this construction, including its impact on motivation for learning. Questions 4 – 8 were designed to gain insight into student respondents' awareness of other social agents' emotions and of emotional influence between social agents in their learning context. I suggest that responding to these questions would influence participants' constructions of emotion. Any of the questions may have prompted respondents to refer to emotions as state or trait constructs. My question design was based initially on my developing understanding of what we can know about other's emotions, but having gained much more theoretically informed understanding of interpersonal emotional interaction and regulation through carrying out this PhD research, I was able to analyse the data in much more sophisticated ways than envisaged when I wrote the questions.

Student questionnaire

1. How has this session made you feel? / How is this project making you feel?
2. Why do you think you feel this way?
3. Do you think this feeling has an activating (makes you want to learn) or deactivating (puts you off learning) effect on your learning? Please give a reason for your response.
4. How does the teacher contribute to this feeling?
5. How do your student peers contribute to this feeling?
6. How do you contribute to this feeling?
7. How do you think your teacher would say they feel whilst teaching this session/project? Please give a reason for your response.
8. How do you think your student peers would say they feel during this session/project? Please give a reason for your response.
9. How does the way this module makes you feel compare with the rest of your degree experience?

Figure 4.3: Student questionnaire

4.3.2.7 Student questionnaire administration

Questionnaires were administered towards the end of a teaching session, chosen by the teacher as being a feasible and useful data collection point. Students were invited to complete the free-text, in-situ anonymous questionnaire administered in Microsoft Forms using a QR code. See Figure 4.3. for the specific questions. Students were advised that this piece of research was independent to their learning but that completing the survey could be an educationally valuable reflective activity for them. I explained that anonymous responses would be shared with their teachers to inform future development. Students were shown the survey questions in advance of volunteering and told that submission implied consent.

4.3.2.8 Follow-up interview with teachers (Stage 3)

To initiate stage 3 of the data gathering process, anonymous student data in the form of an Excel spreadsheet was shared by email with focus group interview participants, or the module lead, for their consideration. This was followed by a 45-60 minute interview to explore meaning in the student data and identify areas for further consideration. Follow-up interview questions (see Figure 4.4) were shared with teachers before the interview. In all but two cases, follow-up interviews were conducted in-person.

Follow-up teacher interview schedule

1. What did you find interesting in the student responses?
2. What did you find surprising?
3. What would you like to do in response to the data, if anything?

Figure 4.4: Follow-up teacher interview schedule

Interestingly, in all but one case the follow-up interview involved only one member of the teaching team. This may be an indication that individuals felt more comfortable discussing the data one-to-one. It could also be that the effects of the pandemic meant the three-stage data gathering stages were more spread out than planned, leading to loss of momentum, teacher time being under pressure and teaching team interaction still being limited. None-the-less, this led to rich discussion about surprising and interesting aspects of the data and action to take.

4.4 Ethical considerations

Further to the ethical considerations embedded within earlier sections of this chapter, below is a summary of key considerations. Imperial College Educational Ethics Review Process committee approved the research (EERP1920-066), all research was performed in accordance with British Educational Research Association guidelines and informed consent was obtained from all participants.

4.4.1 Coercion

Potential teacher participants were directly invited by me therefore, in order to minimise coercion, in the invitation email I highlighted that I understood if they were too busy, and several did decline the invitation. At the time of data collection, I was programme director of the MEd in University Learning and Teaching and some of the teacher participants were current or former students of this programme. Given that these individuals were already educated professionals embedded within STEMM disciplines, it was anticipated that this would mitigate against significant perceived coercion on their part. Where teacher participants were still current MEd students, I mitigated, as far as possible, against any actual or perceived power imbalance by arranging not to assess participants' summatively assessed coursework and advising them of this. Teachers were advised via the participant information sheet that they may withdraw any data/information already provided up until the interview was transcribed and anonymised for use in the final report.

At the end of a selected teaching session, students were given a thorough briefing by me and invited to volunteer to participate in this research study. They were then given time to complete the questionnaire. All students were shown the survey questions in advance of volunteering and told that submission implied consent. Students were advised that their choice to participate, or not, would not affect their educational outcomes. Many students chose not to participate. In the one case where a discipline teacher administered the survey, they left the room as students were completing it.

4.4.2 Anonymity

Student questionnaires did not collect any identifying data and so were completely anonymous. Several included reference to names of teachers and, where this related to a criticism, this was deleted before sharing with teacher participants. Teacher participants were advised that their data would be anonymised at the point of transcription and pseudonyms would be used in the PhD write up and any publications and presentations so that individuals would not be identifiable. When considering the removal of identifiers such as job role and module details, I have balanced possibility of identification of individuals against the value of giving context and depth.

4.4.3 Confidentiality

All data collected was stored securely on an Imperial College password protected laptop and in accordance with the university's regulations and data retention policy. Audio recordings will be retained until after the PhD completion, then deleted.

4.4.4 Sensitive issues

The risk in terms of sensitivity related to participants being asked to reflect on how they felt and why, and the potential for this to directly lead individuals to consider aspects of their learning that caused them distress. During a thorough briefing, students were advised that should this occur there were many sources of emotional support available, listed on a PowerPoint slide, with links. I was guided by Ferrie and Greenwood's (2023) advice that distinguishes between experiencing distress about a life experience and feeling distressed due to participating in research, with the former not being considered "inherently harmful for the distress already exists" (p3). I would also argue that emotion is relevant in any research that focuses on learning experiences but as in this study it was explicitly explored it was important to make participants aware of this and gain informed consent. This was done by showing questions to students in advance of their participation and being explicit about the centrality of emotion in teacher participant information sheets.

4.4.5 Transparency:

Transparency has been upheld where appropriate, taking into account the tension between data sharing and compromising anonymity, and implications of this for reducing data quality should participants be uncertain about how their data will be shared. Extensive data has been included in the Findings sections and additional data are available from the researcher on a reasonable request, within the limits and restrictions of ethical approval.

4.5 Data analysis

In this section, I present and justify the data analysis strategy used in this study. The chosen approach was reflexive thematic analysis as it offers a rigorous yet flexible way for researchers to make meaning of rich qualitative data (Braun and Clarke, 2006). This approach is distinct from thematic analysis that seeks coding reliability, using multiple coders and codebooks (Braun and Clarke, 2019). Rather reflexive thematic analysis values meaning identifiable within data as being contextual, situated and representing multiple realities, with the subjectivity that the researcher brings to the analysis, including their awareness of the context and ability to question associated assumptions, being a resource (Braun and Clarke, 2022).

The process involves the researcher in taking an active role to develop codes that capture units of meaning across the data and to construct themes based on patterns in the analysis, in relation to the research questions. Themes do not emerge from the data, nor are they there to be discovered, rather they are analytic outputs of creative and interpretive work

based on the researcher's theoretical assumptions, contextual awareness and the data (Braun and Clarke, 2019). Table 4.2 gives an overview of the reflexive thematic analysis approach taken, including how analysis of teacher and student data was conducted in parallel. I will also consider each stage in some detail below.

Six phases of Reflexive Thematic Analysis	Analysis approach taken to teacher interviews	Analysis approach taken to student questionnaires
Phase 1: Familiarisation	Actively taking notes during interview. Listening to recordings in full whilst correcting and anonymising transcriptions. Listening to recordings and making notes on my initial impressions on the data, in a different order to the first listening. Reading transcript and making notes on printed copy. Considering PowerPoints generated by Activity 2.	Reading through each dataset once downloaded to Excel. Re-reading relevant dataset and making notes on aspects of interest and questions to discuss with teachers in interviews. Co-analysing and constructing meaning through discussion with teachers and through reflection on their follow-up interview recordings.
Phase 2: Coding	Identifying segments of data relevant to research questions. Creating and applying code labels using NVivo14 (See Figure 4.5) to identify semantic coding (based on participants' explicitly expressed meaning) and latent coding (based on implicit, conceptual, researcher-driven meaning).	Applying codes to data in Excel spreadsheets to capture patterns and meaning across each module cohort and across 'within person' data (See Figure 4.6). Developing summaries for each module case study to group similarly coded data together.
	Reconsidering segments of relevant data and developing codes in light of student data coding.	Reconsidering segments of relevant data and developing codes in light of teacher data coding.

Phase 3: Generating initial themes	Identifying patterns of meaning across the whole dataset, including similarities or differences in emotional experience and attributions. Considering connections between student and teacher data. Asking questions to critically engage with the data, such as: What were the contradictions, misunderstandings and misalignment, in terms of emotional experience, attributions and interactions represented in the data? In what different ways are participants making sense of emotion in learning and why might they do that? Discussing with my supervisor.
Phase 4: Developing and reviewing themes	Re-reading each dataset. Checking each theme tells a convincing story and “highlight[s] most important patterns across dataset in relation to the research question” (Braun and Clarke, 2022, p35). Discussing with my supervisor.
Phase 5: Refining, defining and naming themes	Beginning by establishing the strongest shared themes and writing and orally presenting a synopsis. Developing themes in light of ongoing engagement with literature and professional practice. Reflecting on how themes contribute to overall story. Refining ways in which themes are named.
Phase 6: Writing up	Drafting and redrafting writing. Presenting relevant themes to different audiences, including via publications, conference presentations and workshops, to test and improve persuasiveness of evidence selected and interpretation elaborated under each theme.

Table 4.2: Description of iterative reflexive thematic analysis approach taken (based on Braun and Clarke, 2022).

4.5.1 Phase 1: Familiarisation

Interviews with teacher (Stage 1 and Stage 3) were transcribed verbatim using Otterai software. The Otterai-generated transcripts were then checked for accuracy by listening to the audio and manually correcting where necessary. Unclear text, repetitions, hesitations and exclamations were marked as such. The resulting transcript was a verbatim representation of the audio recording. Transcripts were anonymised and emailed to participants to allow them to redact any detail, within a two-week window, and to give them a record of the interview, in case it was useful. Transcripts were pseudonymised, using

pseudonyms chosen by the participant, or selected by me, if participants did not wish to choose. I found this particularly difficult, as names hold personal meaning and name change can be subject to power relations (Itzik and Walsh, 2023). I could not decide whether and how to reflect aspects of participant identities such as gender, ethnicity and nationality. At the stage of finalising my write-up, I asked teacher participants again for a preferred pseudonym. Table 4.3 lists the teacher participants from each department with their pseudonym.

Department	Pseudonyms of Teacher participants in focus group interview	Pseudonyms of Teacher participants in follow-up interview
Chemistry	Ina, Hubert, Simon	Ina
Electrical and Electronic Engineering	Victoria, Tariq, Brian	George
Life Sciences	Andrea, Clare, Alex	Alex
Mechanical Engineering	Kris, Ironman, William	Kris, Batman
Medicine (module 1)	James, Sanjay, Vivek	Interview not conducted due to Covid19 pandemic disruption
Medicine (module 2)	Antonia, Jessica, Erica	Interview not conducted due to Covid19 pandemic disruption
Physics	Hemal, Sophie, Hasam	Hemal

Table 4.3: Teacher pseudonyms

Student survey responses varied from several words for each question and missing responses to some questions, to very detailed, several sentence responses to each question. I found that, as Braun et al. (2021) experienced, “[b]ecause participants respond by typing responses in their own words, rather than selecting from pre-determined response options, fully qualitative surveys can produce the rich and complex accounts of the type of sense-making typically of interest to qualitative” (p641). In terms of managing partial or incomplete data, I included all students’ questionnaires in my analysis, noting patterns in terms of which questions were less often answered and whether this differed between case studies.

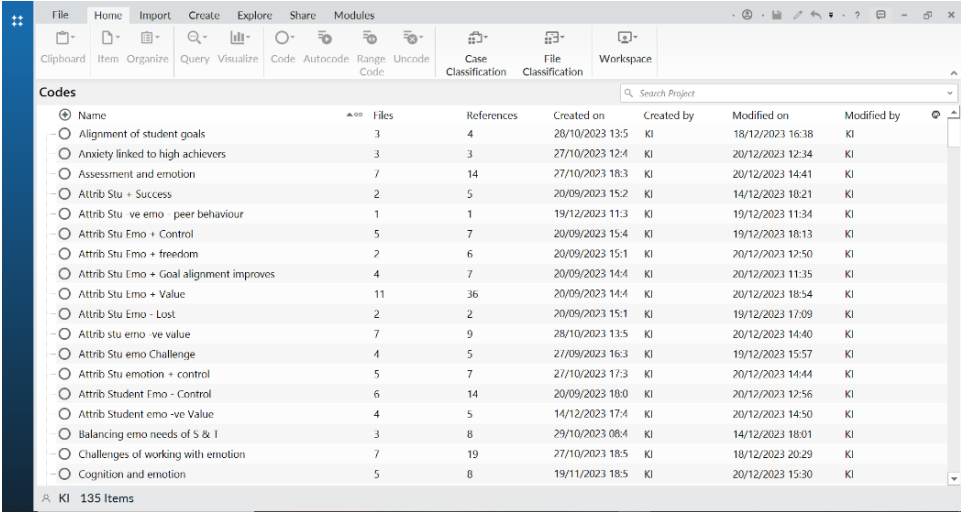
I familiarised myself with the data, as outlined in Table 4.2, over a period of two years, moving between datasets as I collected them and considered them separately and together. I wrote summaries for each teacher interview and each set of student questionnaire data. I continually asked questions to critically engage with the data, informed by my ongoing engagement with literature and educational practice (Braun and Clarke, 2022). For

example, in what different ways are participants making sense of the influence of emotion on learning and why might they do that? What are their inferences about other's emotions based on?

4.5.2 Phase 2: Coding

Given the multiple case study approach taken, in-line with recommended practice, I first analysed data within each case study (Yin, 2018). Initially teachers and students from each disciplinary module case study were treated as a collective case study. I first coded student data then teacher data. I moved regularly between teacher and student datasets, comparing and cross-examining coding to understand relationships between stakeholders' responses and perspectives. Later, I adopted a cross-case synthesis data analysis technique (ibid). At this point, all student data and then all teacher data from across the seven case studies was considered as a collective to look for patterns, including similarities and differences between module case studies.

To aid the management of a large volume of qualitative data, teacher interview transcripts were coded using NVivo14 (see Figure 4.5) and student questionnaire data was coded using Excel (see Figure 4.6).



Name	Files	References	Created on	Created by	Modified on	Modified by
Alignment of student goals	3	4	28/10/2023 13:5	KI	18/12/2023 16:38	KI
Anxiety linked to high achievers	3	3	27/10/2023 12:4	KI	20/12/2023 12:34	KI
Assessment and emotion	7	14	27/10/2023 18:3	KI	20/12/2023 14:41	KI
Attrib Stu + Success	2	5	20/09/2023 15:2	KI	14/12/2023 18:21	KI
Attrib Stu -ve emo peer behaviour	1	1	19/12/2023 11:3	KI	19/12/2023 11:34	KI
Attrib Stu Emo + Control	5	7	20/09/2023 15:4	KI	19/12/2023 18:13	KI
Attrib Stu Emo + freedom	2	6	20/09/2023 15:1	KI	20/12/2023 12:50	KI
Attrib Stu Emo + Goal alignment improves	4	7	20/09/2023 14:4	KI	20/12/2023 11:35	KI
Attrib Stu Emo + Value	11	36	20/09/2023 14:4	KI	20/12/2023 18:54	KI
Attrib Stu Emo - Lost	2	2	20/09/2023 15:1	KI	19/12/2023 17:09	KI
Attrib stu emo -ve value	7	9	28/10/2023 13:5	KI	20/12/2023 14:40	KI
Attrib Stu emo Challenge	4	5	27/09/2023 16:3	KI	19/12/2023 15:57	KI
Attrib Stu emotion + control	5	7	27/10/2023 17:3	KI	20/12/2023 14:44	KI
Attrib Student Emo - Control	6	14	20/09/2023 18:0	KI	20/12/2023 12:56	KI
Attrib Student emo -ve Value	4	5	14/12/2023 17:4	KI	20/12/2023 14:50	KI
Balancing emo needs of S & I	3	8	29/10/2023 08:4	KI	14/12/2023 18:01	KI
Challenges of working with emotion	7	19	27/10/2023 18:5	KI	18/12/2023 20:29	KI
Cognition and emotion	5	8	19/11/2023 18:5	KI	20/12/2023 15:30	KI

Figure 4.5: Illustration of coding of teacher interview data in NVivo



Figure 4.6: Illustration of coding of student questionnaire data in Excel

Based on my contextual awareness, from early on I was able to develop codes that captured both surface-level, semantic meaning (based on participants' explicitly expressed meaning) and more conceptual, latent levels of meaning (based on implicit, researcher-driven meaning) (Braun and Clarke, 2022). For example, as well as coding how teacher participants explicitly referred to working with student emotion, I could identify at a latent level, within their focus group interview data, how they attempted to regulate each other's emotion and how, by talking about emotion, they were influencing each other's emotional awareness, through a process of emotion socialisation.

As the perception that STEMM students and teachers reciprocally influence each other emotionally was based on my experience and was not empirically informed, an inductive, or data-driven, orientation, as opposed to a theory-driven approach, was initially adopted (ibid). Coding was iteratively developed from students' and teachers' responses, across the seven case study contexts, that referred to factors that influenced their emotional experiences, including each other (see Figure 4.7). Once the coding process identified across datasets the various ways in which student peers and teachers influenced each other's emotional experiences as being an important dimension in the data, a theory driven approach to coding was applied to some sections. For example, one theory used explicitly in the analysis was Gross' (2015) 'Process model of emotion regulation' to investigate the nature of this phenomenon in more depth (see Chapter 7). A table indicating the relationships between later stage, refined codes from student and teacher datasets and themes are presented in Appendix B.

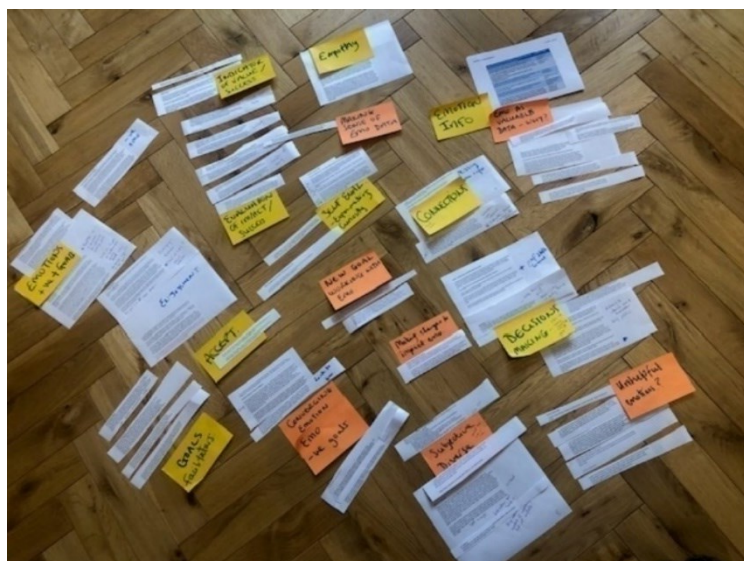


Figure 4.7: Illustration of developing codes to capture units of meaning across the whole dataset

4.5.3 Phase 3: Generating initial themes

From the coding process, I developed tentative themes based on my interpretations of patterns in meaning across the datasets, in relation to all three research questions. Themes were developed around ‘central organising concepts’ (Braun and Clarke, 2022) that I identified as being central to how both student participant responses and teacher participant conversations related emotional experiences and emotional interactions to the influence of

4.5.4 Phase 4: Developing and reviewing themes

Phase 4 involved checking that each theme contributed to a convincing narrative and ensuring that, in light of the research questions, together they captured the most important ideas across the whole dataset (Braun and Clarke, 2022). At this point, themes were combined and discarded. For example, themes that were framed as individual emotional experiences, such as time management, were reconsidered in terms of more interpersonal meaning and social comparison was considered in more depth.

4.5.5 Phase 5: Refining, defining and naming themes

By this point, my further engagement with the data and literature indicated that there were strong points of connection between students’ and their teachers’ emotional experiences across all 7 case studies. At this point, I defined and named three overarching themes, each of which, captured how students and teacher influenced each other emotionally. Validity of these themes was increased by my “in-depth awareness of these teaching and learning contexts through [my] role as educational developer, and the recursive nature of data collection that related and triangulated datasets at every stage (Denzin, 2009)” (Ippolito and

Kingsbury, 2024, p3).

4.5.6 Phase 6: Writing up

Writing up was an iterative process. A particular challenge was deciding whether to write up the findings chapters based on a.) themes within an individual module case study, but across student and teacher datasets, or b.) as chapters based on themes cutting across the module case study datasets. The former risks repetition, and the latter risks losing rich insights on context-relevant detail, due to fragmentation.

Analysing data both within and across my seven STEMM module case studies, enabled me to establish that, although there were context-specific differences impacting on emotional interactions, there were many important similarities. On this basis, I have structured my findings to present themes and sub-themes present across the module case studies, rather than themes within each disciplinary case study. This enables stronger and more valuable observations and recommendations to be made, avoids repetition and creates a better reader experience. I hope to have embedded enough context-relevant detail where relevant.

At later stages of data analysis and when writing up, I chose to focus on the interactions and relationships between emotional experiences reported by participants, rather than any one individual's emotional experience. Having taken a social constructionist approach theoretically and methodologically, I believe that the study's value comes from illustrating how the individual and social nature of emotions are continually interacting and influencing each other, and I have tried to capture this in my study in pragmatic but methodologically underpinned ways. As I hope my findings will be of interest to university teachers and educational developers, this analysis of emotion at a whole class level, rather than individual student level, but that reflects individual variability, may be useful for educational decision-making. Student quotes are reproduced as typed, to retain authenticity.

4.6 Chapter conclusion

This chapter has set out approaches taken in this study to gather and analyse data in order to address the research questions. This was informed by a social constructionist and pragmatist paradigm that enabled exploration of the ways in which the students and teachers in each of the module case studies contributed to social construction of emotional experiences and how this can inform future practice. Data gathered from teaching teams, via focus group interviews, from students, via in-situ questionnaires, and during follow-up

interviews with teachers to discuss student data, was analysed using reflexive thematic analysis. An iterative familiarisation and coding process enabled the development of codes within case studies and across all seven case study datasets. Overarching themes and themes were developed to capture the most meaningful patterns across the dataset, in response to the research questions. This process also took into account existing literature and theory, and relevant contextual factors, including how to make valuable contributions to thinking about the role emotion in university learning and teaching. These will be presented in the following four chapters.

5. Findings: Overview and introduction

5.1 Overview of findings from student questionnaires

280 students from across six STEMM discipline cohorts submitted voluntary responses via a questionnaire and these revealed some important findings, that I summarise here. Students who chose to participate were readily able to identify an emotional experience that was relevant to them when asked, in relation to a particular teaching session or project. Most striking was that in data collected from within each module cohort, students reported a large variety of emotion and also great variation in attributions; even when the same emotion word was used, the reasons why they thought they felt this way were diverse. Data collected in each of the disciplinary contexts revealed some differences in emotional experience, but this was less striking than emotional variation within a cohort. These differences can be understood in terms of difference in educational design, teaching and learning approaches, as well as relationships with peers and teachers and will be illustrated, explored and linked to recommendations, where valuable. Taken together, this justified the decision, set out in the methodology, that to best address the research questions it was more helpful to consider data across the discipline-based module datasets rather than compare between discipline-based module datasets.

Many student respondents expressed feeling several emotions at the same time and often these described positively and negatively valenced, high activation emotions, for example feeling excited and stressed. Many of the emotions identified were aligned to Pekrun's (2006) achievement emotions and, to a lesser extent, epistemic emotions (Vogl et al., 2020). There was also evidence of social emotions, particularly relating to students' feelings about how they compared to their peers, in terms of perceived achievement, and to group contributions. The latter primarily included frustration at others' lack of contribution, disappointment at not being able to contribute more or enjoyment, gratitude and satisfaction regarding collaborative learning. All 280 students were willing and able to make well-reasoned attributions for the emotions they experienced. The unexpectedly diverse range of emotional experiences described and the attributions for these, even within a cohort of students experiencing the same session or project, gave valuable insight into factors that contribute to the construction of emotion in STEMM academic learning. These reported emotions could be interpreted in relation to the respondents' goals, including unarticulated, misaligned or conflicting goals, and seem to reflect whether they perceived the session or project as enabling them to achieve these goals. Respondents' goals within-person and

across the cohorts were a mixture of academic, social and, to a lesser extent, professional goals. Some responses reflected tension between personal goals and the perceived goals of peers and teachers. Almost all respondents, including those who reported negative emotion, either directly in relation to the identified session, or longer-term learning, reported that their emotional experience was activating, in that it motivated them to pay attention, put in effort and/or collaborate with others, rather than deactivating.

Student respondents generally showed a high level of awareness of how peers, teachers and they themselves contributed to their emotional experiences. This enabled very interesting and surprising insight into ER within and between individuals in STEMM university classrooms, from a student perspective. A small number of students chose not to answer these questions, and this was higher in Year 1 cohorts. Year 2 students reported using a wide range of strategies to regulate their own and other's emotions. Their responses suggested that they were more aware of the value of collaborative learning and they were more likely to be explicit about what they contributed cognitively and emotionally to these interactions. Conversely, Year 1 students made less reference to the negative influence of social comparison on emotion than Year 2 students. Taken together, this may give insight into the process of emotion socialisation within UG learning contexts.

Many students, although not all, readily articulated how they thought the session or project would be making peers and teachers feel. In terms of perceived peer emotion, this ranged from those who seemed confident in their inference of how their peers felt, with some referring to evidence such as observations of emotional expressions and conversations. The majority of students reported that they thought peers would feel similar to them. Those who reported very strong negative emotion were more likely to assume that their peers felt differently, than those who felt positive. Students demonstrated a wide range of intuition into how their teachers might be feeling. Many gave insight into what they based their inferences on and this often related to their awareness of teachers' goals and to what extent they thought that the teacher was achieving these. In contrast, some students' responses raised issues that may have related to lack of awareness of teacher goals, misalignment with teacher goals and what some students perceived to be a lack of empathy, or academic or emotional support.

5.2 Overview of findings from teacher focus group interviews

Given the purposeful sample of 23 teachers in this study were chosen on the basis of their engagement with active learning, it is perhaps not surprising that they were readily able to identify a range of emotions that they were aware of their students experiencing. They also made a range of well-considered attributions for these. There was much alignment between teacher perceptions of their students' emotional experiences and what their students' responses revealed about their emotions in the process of these specific learning events. Exceptions to this will be elaborated upon in the following chapters. Unsurprisingly teachers did not explicitly conceive of emotions as socially constructed, but neither did they express a strong conceptualisation of emotions as innate and universal entities, that are triggered by specific events. Their responses did give insight into factors that contribute to construction of their own emotion and how they contribute to construction of student emotions, as will be discussed.

Data from teachers gave a strong indication that they understand themselves to have a role in working with learner emotion. Teachers did not explicitly refer to how or when they regulated learner emotion in any systematic way, but through the process of reflective conversations during focus group interviews, knowledge about how teaching teams worked with emotion in their teaching practice was socially constructed and shared. The data included robust evidence of teachers using their own felt emotion and their inferences of past and current student emotions to guide their educational decision-making at every stage of the process. Conversations indicated that a more accurate picture of the range of student emotion and more nuanced explanations for these would be useful. The emotion information produced, and understanding constructed through this study, both during conversation with fellow teachers and via student questionnaire data, seemed to be of value to teacher participants. Teachers also talked less about their own emotions, possibly as most questions focussed on student emotion, but it was evident that teaching is a very emotional endeavour as teachers described regulating their own emotions and those of students. Often unpleasant emotions that teachers described experiencing were related to factors that they perceived as blocking their teaching goals. Conversely, positive emotions were often related to achieving their varied teaching goals, especially when these were considered to be difficult goals, related to challenging contexts, including active and collaborative learning.

Data across all datasets clearly indicated that emotional experiences in the context of STEMM university learning and teaching are shaped by individual's educational goals, their social interactions with others and, through this socialisation process, their awareness of each other's goals, and progress towards and achievement of these goals. Given the patterns in the data I have indicated in this Findings Overview Chapter, and the tendency for emotion to be ignored in Science-based education, as indicated in the Literature Review, I believe that this study can tell a more powerful story through themes that cut across the seven STEMM disciplinary datasets, rather than by comparing and contrasting findings between each module case study. In this way, data can be used to illustrate nuanced interpretations of how learning and teaching experiences in STEMM HE contribute to constructions of emotion and how emotions contribute to learning and teaching.

The combination of student and teacher perspectives offered valuable insight into interesting and novel findings related to the ways that student peers' and teachers' emotional experiences interact. Careful and iterative analysis of the data revealed three clear points of emotional connection in these STEMM learners' and teachers' experiences. These were identified based on reported emotion being intensely felt, on noteworthy similarities or differences in emotional experiences between student peers and teachers, and on complex, contradictory social construction of emotion and meaning, that can be helpfully unpacked. These three themes enable useful answers to the research questions and offer nuanced ways of connecting and understanding existing tensions and gaps identified in the Literature Review. The three themes are:

Knowing: Transforming epistemic goals and relationships with knowledge

Evaluating: Social construction and appraisal of goal achievement

Empathising: Reciprocal emotion regulation for complex goal achievement

The following three Thematic Chapters explore these three themes in turn.

This idea of emotional connection does not suggest that teachers and learners construct the same emotions as each other, in the sense that teachers 'get' students emotions (Walker and Palacios, 2016), or vice versa. Owing to our differing perspectives and alignment with events around us it is unlikely that people's emotions ever fully converge (Parkinson, 2019). Rather, emotional connection refers to how learners and teachers in STEMM settings contribute to each other's social constructions of emotion and have more similar emotional experiences than we might expect.

6. Knowing: Transforming epistemic goals and relationships with knowledge

6.1 Chapter introduction

The following chapter presents findings that illustrate ways in which student and teacher participants' emotional experiences were closely associated with their various knowledge-related beliefs, goals and approaches. Furthermore, I examine data to gain insight into how learners and teachers influence each other's emotions as they develop their understandings of what it means to know in their STEMM discipline, and their relationships with knowledge. In doing so, I examine the way their cognitions and emotions interact to shape their learning, development and relationships. Sub-themes within this larger theme are presented under sub-headings and, in accordance with reflexive thematic analysis, findings and discussion will be integrated to enable me to deepen analysis by contextualising the themes in relation to relevant literature, theory and wider contexts (Braun and Clarke, 2022).

6.2 Emotion in evolving epistemic beliefs and goals

As set out in the Literature Review, emotions are strongly related to academic goals, including cognitive goals, associated with the need and desire to gain knowledge and develop understanding. Given their entry requirements and pre-university educational achievements, it is likely that many student participants involved in this study have an academic self-concept that is based on being knowledgeable and cognitively competent, particularly in scientific domains (Arens et al., 2020). However, university-level study presents a gear change for learners in terms of expectations around their engagement with knowledge, including handling an increase in volume and complexity. This may require them to develop new epistemic beliefs about the nature of scientific knowledge and knowing, and associated goals (Sandoval, 2015). This is a transformative process that can result in a profound sense of disorientation (Mezirow, 2009), in which competency and self-concept is questioned. If the remit of HE is to challenge and change learners' relationships with knowledge and, in doing so, challenge and change their goals, it should be expected that such transformation will be frequently emotionally charged and seldom emotionally neutral. This chapter offers insights into how students and teachers navigate this, socially constructing emotion as they do so.

The data indicated that students' strongest and most varied emotions were constructed in relation to grappling with unfamiliar, voluminous, complex and sometimes ambiguous knowledge. For example, the responses of 65 Life Sciences (LS) students learning about statistics and programming reported a continuum of emotional experiences that represent three broad groups of responses observed amongst participants. One group described feelings of 'getting lost' and 'falling behind', based on their perceived inability to readily grasp, easily recall or competently apply scientific and technical concepts, as represented by Student117:

"It made me feel really stupid if I have to be honest – I feel so lost all the time and there are so many words and rules to remember. The teaching makes sense in class but as soon as I step out I am completely lost again. I want to say I'm motivated but seeing everyone miles ahead of me in understanding is really demotivating" (Student117, LS).

Representative of the second group, Student77's positive emotional experience is based on their sense of relative progress and cognitive development: "I feel decent after this session[...] I have for once fully understood the content, and mostly caught up with the speed of my teammates" (Student77, LS).

The third group's responses reflected greater awareness that gaining, and learning to apply, new knowledge is characterised by mixed valence, including some discomfort. In the quote from particularly insightful Student118, they refer to a cycle of emotion involved in this process and its value for building resilient self-efficacy (Bandura, 1994), linked to academic goal achievement:

"It made me feel excited to learn, a bit sad for how slow I interpret the content and happy when I solve a question on my own...It is kind of a circle. You get discouraged a bit in the beginning especially when you realize how stupid you are. But when you get it done, you will regain and reconstruct your confidence, a[n] even stronger one than before" (Student118, LS).

The insights data gave into the diverse range of student emotions and their knowledge-related attributions, even in the same setting, suggested a variety of epistemic beliefs and cognitive goals. This echoes Baxter Magolda's (2010) 'Epistemological reflection model' that proposes that university learners progress through four stages of knowing as their beliefs about knowing change, influenced by their development and the social context (Bock, 1999). Based on the data, I suggest that these diverse emotional experiences are influenced by

where students' epistemic beliefs are positioned on this continuum from 'absolute knowing' (knowledge is seen as certain and the goal is to obtain correct knowledge), through 'transitional knowing' (some knowledge is uncertain, teacher does not always know, learning involves exchanging perspectives) and 'independent knowing' (accepting most knowledge is uncertain, sharing views with peers expands learners' abilities to think for themselves) to 'contextual knowing' (being able to weigh up, judge, integrate and apply knowledge, within a specific context). How students made meaning of these emotions seemed to relate their ability to set university appropriate, cognitive goals. Students whose responses implied a transition to conceiving knowledge as less certain and negotiated, and who recognised the constructive potential of cognitively interacting with peers, reported more positive emotion, including in relation to the knowledge and each other: "Peers help to form consensus answers and consider other viewpoints which amplifies those feelings of interest" (Student38, LS).

I suggest that Student117, who seemed upset about not achieving their goal to remember 'words and rules' had beliefs more aligned with absolute knowing. However, for their teacher, Alex, the learning outcome was not committing statistical and programming techniques to memory. Rather, his goal was that students developed the confidence to "go off and Google the hell out of it and try and figure out what it is that you need to physically write" (Alex, LS). He recognised the cognitive complexity faced by these novice life scientists learning R programming simultaneously, with not just using statistics, but applying them to biological contexts. This resonates with Hartikainen et al.'s (2022) reports of emotional meltdown in engineering students who struggled to understand how to interpret feedback in unfamiliar programming tasks.

As this chapter will illustrate, teacher participants across the STEMM contexts studied recognised their role in shaping students' epistemic beliefs and relationship with disciplinary knowledge, although they did not use these terms. They appreciated that the transition created an understandable source of difficult but inevitable emotion for students. In many cases, this challenge provided the more activating emotional experiences for teachers, countering what could become repetitive delivery of even the content they were more interested in and curious about. For Ina, supporting students in transforming their epistemic beliefs was both an aspirational goal and potential source of frustration:

"I think the end of first year, to be completely comfortable with the idea that there are no right answers is asking a bit much, but I would say towards the end of the degree. Certainly if we haven't achieved that, I don't think you're really understanding what university study is" (Ina, CH).

In terms of how this is supported, Ina's colleague, Luke, observed this epistemic shift occurring through "final year projects, and so on, when practical work starts to look more like real research" (Luke, CH), but commented that approaches such as enquiry-based Chemistry labs aimed to move this transition earlier within the degree.

Alex saw the need for emotional development alongside cognitive, to facilitate this transition:

"actually most of that threshold is mainly emotional...because it's not being sort of daunted by the fact that you're receiving [programming] error messages. That you've got some confidence to be able to look at those error messages and try to interpret them" (Alex, LS).

Possibly as a result of his approach to teaching programming and statistics, some of Alex's students demonstrated 'transitional knowing' beliefs (Baxter Magolda, 2010). One, who admitted statistics were not their "forte", reflected that "I try to stay positive and open, I also make sure to ask as many questions as I can within my group so I think I'm open to learning as much as possible" (Student119, LS).

Explanations for why these students appeared to develop their understanding at these apparently unsteady and differing rates, and experienced varying associated emotion, include the process of grappling with troublesome knowledge (Perkins, 2006), including the conceptually challenging knowledge common in STEMM HE. This involves individuals passing through liminal states between becoming aware of challenging concepts and them opening up a new way of thinking (Meyer and Land, 2006). Some students seemed more willing to accept this liminal state than others and teachers talked about how they tried to normalise the feelings that they knew this created, as Kris illustrates: "I even tell them, 'if you're confused about things, that's perfectly fine. Don't worry about it'" (Kris, ME). This echoes Cousin's (2006) advice that empathising can help students to work with troublesome knowledge and progress through liminality.

In these ways, teachers demonstrated their 'contextual knowing' (Baxter Magolda, 2010), continually weighing up how to support students with emotions inherent in challenging learning. In turn, this could be difficult emotionally for teachers and influenced how they used their emotion-related knowledge:

"Some of the nuances of the thermodynamics course, I know for a fact there are some students in the cohort who are never going to get it, and not only that, would find it very, very hard to...understand some of the most difficult parts...That's actually horrible to know" (Hemal, PH).

Data suggested that these teachers also hold differing and shifting epistemic beliefs. Ironman's quote illustrates the emotional discomfort, possibly created by misalignment between a teacher's goal to meet students' knowledge-related expectations regarding appearing knowledgeable, and their own epistemic belief that, at this level, no one knows everything (Ippolito and Kingsbury, 2024).

"Personally, I really, really struggle with those moments when the students ask me something that I can't answer. I really, really hate that...Obviously, I cannot know everything, but still, I just can't deal with the feeling"
(Ironman, ME).

His colleague, Kris, could rationalise this, understanding that discomfort, on both teacher and student sides, comes from the uncertain nature of the knowledge students are required to work with in order to develop as independent knowers, and teachers can have a role in modelling this:

"yes, it's frustrating if they ask a question, and we don't have an answer to it, and it's not really good for your ego...I've got the same frustration, because sometimes I've got this feeling, I should know this, I'm here to teach these guys. But actually, what we're trying to teach them is that we don't always know the answer" (Kris, ME).

Other teachers referred to explicitly modelling the challenges in working with such high volumes of knowledge. For example, James referred to highlighting the cognitive limitations of even high functioning human brains, which, if ignored can lead to distracting emotion, exacerbating the problem further: "I've got no problem standing up and saying, 'Oh God, leaky brain's kicked in again, hang on, and I'll come back to you in a minute'" (James, MD).

These quotes, and particularly Alex's below, draw to attention the risks in 'showing vulnerability' in a culture that so prizes being knowledgeable and illustrate how teachers balanced these risks against modelling sustainable relationships with knowledge.

"I give live demonstrations myself, I'm constantly like, 'Oh, I forgot how to use this function. Let me just look at the help function'. Almost to give them [students] an insight of like, how I do it, because obviously, I make mistakes when I code. And actually, that causes me a bit of anxiety, that I don't look like I'm superb, but...I feel like it's actually important for them to see...and I do things wrong...And then I'll figure it out" (Alex, LS).

In the process of teaching, Alex described paying attention to balancing his teaching goal of normalising mistake-making in coding, to reduce student fear, and his goal to appear in control and that he knows what he's doing. I suggest that both impact on social constructions of emotion and knowing in this learning setting, including fear of not knowing and pleasure of coming to know something after cognitive struggle.

6.3 Teachers' relationships with disciplinary knowledge

Some teachers referred to how their own knowledge-related emotion influenced students. This often related to positive, activating emotion such as enjoyment and enthusiasm. Clare recognised this in her own practice, also observing that diversity of passion within teaching teams can be beneficial:

“plant biology stuff, that's the bit I can certainly get excited about and be enthusiastic about. And, and I would therefore kind of try extra hard to get students to enjoy the bits that I enjoy, if that makes sense. That's probably a bit selfish, but it's nice that we all have slightly different um interests...They really can tell when you're teaching what you love” (Clare, LS).

Student187 reported on their tutor's perceived relationship with knowledge that was closely related to their project and this seemed to create a positive shared emotional connection: “I think my tutor felt energized by the different designs which [our] group is coming up with. My tutor has done research in our area of design interest, so I felt that he relished the chance to reuse old knowledge” (Student187, ME).

Generally, being able to teach about knowledge they felt interested and competent in was considered by teachers to be an emotionally positive experience. However, this could give rise to negative emotion depending on how teachers felt about aligning their knowledge with imposed teaching goals and accepting compromise. For example, Jessica talked about:

“being kind of forced to make your own research and your own disciplinary knowledge fit into a new area that you're not used to fitting it in...and so I can find that quite frustrating, especially when you're time bound as well. And so all the nuances that I normally want to be in there have to come out. And so there's that element of not getting it, but if you don't understand this topic, it's kind of like, it partly would help if I could give you more of it, but I can't” (Jessica, MD).

This negative emotion could be attributed both to barriers to instrumental goals (Taxer and Gross, 2018), such as helping students fully understand, and identity goals, relating to perceived competence as a teacher and researcher.

University teachers enjoy, and are often lucky enough to see, some novelty in student work. A challenge, when moving regularly between teaching first year UGs and PhD students, as well as working on their own research, can be calibrating expectations of knowledge complexity that different students are working with. This also involves shifting from researcher goals (e.g. to innovate) to teacher goals (e.g. to support). George talked about what he perceived to be a lack of novelty that he was frustrated into resolving:

“since students came up with, with projects, the quality was very bad, generally... some ideas were not interesting, or they were trivial...[Due to] lack of knowledge of what other people did, generally, students do not realise that there are so many people in the world that whatever they can come up with someone else has done, right...every year there were like four groups, that were doing...a device that tells you if you're falling, like for elderly” (George, EEE).

His solution was to design in an innovative student-led quality assurance process, requiring students to peer review each other's project proposals. Students were then exposed to a diversity of knowledge and given an active role in co-constructing knowledge. This also created the possibility of influencing student emotion by increasing their balance of control in the project selection process.

6.4 Negotiating what is valued as knowledge

A substantial source of emotional interaction between teacher colleagues and students related to negotiating what constitutes knowledge in a given STEMM discipline and curriculum, and the value conferred to it. Teachers reflected the conscious and careful choices made, or otherwise, about what knowledge to introduce at each stage and how, as well as giving insight into the competing factors that influence this, as Brian explains:

“with maths in particular, there's a lot of pressure from those who want to teach advanced modules...What they want to do is to turn up and talk a lot about applications. But they want to do it in a really complicated way and launch straight into lots of maths to prove things. So there it is application focused, it just relies on a lot of background theory. And they expect... the

students just to be able to recall this theory straightaway and keep up with that, so that they can, they can dive into the exciting stuff... the most prestigious academics want to teach their signature modules in the final year” (Brian, EEE).

Brian’s quote reflects sentiment of teachers that experience frustration because their goal is to develop balanced curricula that engage students’ interest, by combining theoretical knowledge and knowledge application throughout, and provide supportive knowledge scaffolding. When different teachers’ educational goals are misaligned like this, one teacher’s excitement contributes to another teacher’s construction of frustration and risks students feeling bored, confused or anxious.

Given freedom, teachers reported choosing to teach knowledge they think is of value, based on its currency, utility, or even the emotion it provoked in them as learners, and provokes in them as teachers. A mismatch in student and teacher goals and emotions seemed to occur when their view of what is knowledge of ‘value’ was not shared. This could occur when teachers based their judgement of value on how knowledge is used in professional practice, insight that few UG students have. This can lead to negative emotion on both sides, as Victoria explains:

“sometimes it's frustrating because they sort of, they don't see the value of [project management]. They think that being an engineer is just about the technical stuff. There is a minority who do see the value, but they are more the ones who have done a year in industry” (Victoria, EEE).

Where recognition of what knowledge is of value became aligned, often through students’ experience, this led to positive emotion. In line with Control Value Theory of Achievement Emotion (Pekrun, 2006), Student53, quoted below, suggests that the combination of realising the value of their knowledge through application, at a time when they felt in enough control of the knowledge, led them to construct a positive and activating emotion:

“I feel happy and excited that I am progressing as an engineer. I would not have been able to approach working on a project like this with my academic knowledge at the start of the year. My achievements during the project have shown me that I have made greater progress in my learning of electronic engineering than I thought I had” (Student54, EEE).

Furthermore, it is possible that this group project design, and reflection on it through completing this study’s questionnaire, contributed to their production of meta-cognitive knowledge regarding their unexpected progress towards their desired goal.

Some teachers described priming students to see value in less tangible knowledge, that might not otherwise be appreciated. As medical educator, Antonia, explained, as well as being tacit knowledge, this is challenging as it involves independent and even 'contextual knowing', acknowledging different perspectives and judging their relevancy:

"I have said year on year to students, you know, Imperial students will acquire the knowledge if they work hard, they will gain the skills if they practice diligently enough. What they cannot get is this wisdom. And that is what makes the difference between a very good doctor and the very best doctor to me...It's that ability to, to look at what's going on in the round, take different perspectives, consider what the options are... And we introduce that concept early on in our sessions with them" (Antonia, MD).

Appreciating value also came from the perspective of not having benefitted from gaining useful knowledge as a student, and having experienced difficult emotions as a result, as tutor, Vivek, explains:

"I think the whole clinical and science integrative module is very interesting, and certainly something that I didn't have...at medical school at all, to try and understand why the basic science that you learned, why is that important as a doctor. Stuff that I only realised, you know, in my later years of medical school after I graduated, and by then it's too late. Or you then have to kind of go back and relearn it yourself" (Vivek, MD).

Using TBL to actively involve students in integrating clinical and scientific knowledge was relatively new in this medical curriculum and the interaction of complex concepts, coupled with collaborative learning drove up intrinsic cognitive load (van Merriënboer and Sweller, 2010). This challenged learners and teachers and required paying attention to emotions of all involved, as James recognised:

"We can go from looking at, you know, cellular proteins to talking about empathy.... That's a high level of challenge for any tutor.... We always want [tutors] to relay to the students... 'you may ask us a question, we may not know the answer and that's alright, you know, because no one knows everything. And you need to get used to that as a future doctor'... That's giving a comfort level to your tutors. But I think it's also in terms of managing the emotion of your students" (James, MD).

Handled well, as James describes, it also created opportunities for teachers to model how pressure of knowledge overload and uncertainty is managed in professional practice (Ippolito and Kingsbury, 2024).

In the context of interdisciplinary knowledge integration, Jessica highlighted how, for teachers, emotion might be constructed in relation to uncertainty regarding professional identity:

“where you're actually bringing together lots of different types of and disciplines of knowledge...I sometimes feel like the imposter because I'm not, I'm not a medic, um, but we've all got very different types of knowledge. And there's kind of an uncertainty about how it all fits together. And so we explore that within our, our own little teaching team, as well as with the students” (Jessica, MD).

She stressed the importance of clarity within teaching teams and with students regarding how integration of diverse knowledge brings educational value, as this empowers individual knowledge contributors.

Data indicated that students who had mainly experienced more theoretical STEMM learning previously may not engage as fully as teachers would hope with more practical aspects of the course, especially if they were underconfident, as some students reported. This was frustrating for teachers who were generally passionate about how theoretical and procedural knowledge interact. For example, Simon illustrated, in the context of Chemistry lab teaching, how teachers' emotions may be influenced by the extent to which students enabled teachers to achieve their goals. That is, teaching goals that were underpinned by what knowledge is valued in a specific STEMM discipline: “get them to understand that there is an intellectual challenge to practical chemistry. Not that you think in the lectures and in the lab you just go and switch your brain off and switch your hands on” (Simon, CH).

Within the Physics cohort, the session under focus involved students working in their group to develop a concept map, an activity designed to support collaborative consolidation in preparation for revision. The emotions constructed in relation to the value of this process were diverse, with several students concluding that it was a valuable tool for helping them take control of concepts related to oscillations and waves, but the majority seeing it as an unwelcome distraction from engaging with valuable Physics knowledge, as the two quotes below illustrate:

“I completely forgot about the use of this learning tool. It gives me another method to study. The teacher was enthusiastic and made me feel a bit more excited about going home to try it” (Student251, PH).

“[I feel] indifferent, i found this a little useless. there is complicated physics that we could have been doing instead. We have so little time where we get in-person teaching that to use it in this way, i don't think it's a good use of our time” (Student280, PH).

6.5 Learning to cope with uncertainty

Learning to cope with uncertainty was of common interest amongst teachers, who generally considered it to cause difficult but important emotional challenge for students. Data offered valuable illustrations of uncertainty in UG STEMM education and how teachers and students made meaning of its educational value and emotional influence. The discomfort of uncertainty in learning was considered to be a new emotional experience for most students, one that distinguished HE and prepared them for professional STEMM futures. Uncertainty was characterised as engagement with knowledge being more open-ended, less defined, both in terms of process and outcome (Ippolito, under review). Victoria's quote expresses typical sentiment regarding the initial impact of uncertainty on students and reasons why:

“They are not quite sure what it is or how to, because it's open-ended and up 'til now everything that they have had both at school and in the department has been quite prescriptive. Now you have a problem sheet, you have an exam...they know there's a process. They get a result. But now, all of a sudden, it's like, well, here is a challenge. There's no right way of doing it and there's no one universally correct solution. And that creates anxiety and confusion” (Victoria, EEE).

Some teachers considered this emotional difficulty to be compounded by students' perceived identity as high achieving learners, used to having the knowledge they need. This shift towards unknowns involved experiencing uncomfortable emotion and developing unfamiliar strategies, as William explains:

“You have to formulate it yourself. And sometimes you're just gonna have to kind of guess, and I think that's where the frustration comes in. They're put in a situation where they no longer know how to do what they need to do. And they feel they should” (William, ME).

He also highlights the potential emotional impact on student identity goals especially amongst individuals who feel they should 'know how'. William's use of 'you', 'yourself' and 'you're' was common amongst teachers when describing students' experiences. I interpreted it as indicating how teachers often considered their own past, and also ongoing, challenges with knowledge when considering student emotion.

Students characterised being uncertain as working with unfamiliar content, in unfamiliar ways. From their perspective, this did not necessarily contribute to negative emotion, especially when students felt supported cognitively and emotionally by a combination of teachers and peers, as Student151 exemplifies:

"This session has made me feel a bit uncertain around some of the work but working with my team has made me happy. The work we were set to analyze was quite challenging to tackle and quite different from what we have done previously... Dr. Alex is really good at explaining and setting exercises that deepen my understanding...The GTAs are also really good and I always come away understanding more and feeling more confident" (Student151, LS).

Additionally, teachers characterised uncertainty as relating to students' struggle with accepting the uncertainty of knowledge inherent in moving from 'absolute knowing' to 'transitional knowing' (Baxter Magolda, 2010): "What a lot of our students find very difficult, there is no right answer" (Ina, CH).

Hubert's quote illustrates how it is important that teachers scaffold the desired shift in epistemic belief in order that students can engage effectively with more cognitively complex tasks that require 'independent knowing' and creativity:

"they were struggling with making their own creative decisions because they didn't know what's a good decision. What's a bad decision? Even though there is no right answer" (Hubert, CH).

As William highlights, supporting students in learning how to cope with uncertainty and confusion contributed to teachers' emotional experiences, which in some ways were considered similar to, and interconnected with students':

"we go into it with, with the same level of uncertainty the students do, to some extent. Okay, from my point of view, that's more, that's worse, because I didn't really study this as an undergrad... You walk into a room,

there's 20 odd students in there, you don't know them. You don't know how they're going to work together, you don't know what problems you're going to encounter, you don't know whether you can direct them to actually solve the problem" (William, ME).

This is an interesting example for thinking about the extent to which learners and teachers can be perceived as sharing emotional experiences. Parkinson's (2019) conception of emotions as 'relational orientations', where the most relevant contextual feature is the object that emotion is focused on and individual's orientation to that object, is useful here. William highlights a salient object as being uncertainty and he suggests that he and his students share a similar orientation to this object. He then reflects that his orientation is more problematic because of his lack of knowledge and the way that this contributes to his goal of directing students to solve the problem. That William still refers back to his 'missing' UG knowledge even though he has a PhD in Engineering again highlights the power of disciplinary knowledge in STEMM. This notion of missing knowledge could be related to the nature of STEMM being built on logical building blocks. Or perhaps it relates to more general uncertainty that teachers may have about how to manage unpredictable questions from students, without eroding their perceived knowledge expertise that may underpin their confidence as a teacher and the relationship with the students. This is a risk when knowledge is such a salient object, and, as William suggests, whether orientations and goals related to that object align or otherwise, can result in difficult emotional interaction.

Teachers reported taking different approaches to supporting learners with uncertainty. In the redesigned Year 1 Electrical and Electronic Engineering module, the group project had been relocated at end of term three, after exams. It was "frontloaded" with two weeks of theory-based input, rather than this being integrated over a term as before, with office hours, drop-in sessions and lab support now offered for the remainder of the project. Victoria explained how this was to give students a greater perceived sense of control, through increased knowledge, but that this support was carefully balanced against opportunities to develop independence and tolerance for uncertainty:

"they have all the knowledge, well they think they have all the knowledge, they need to complete the project. So they feel a bit more assured...But at the same time, there was some freedom, because eventually, you know, we want them to become independent learners. Uncertainty is a huge part of...engineering because you start tackling a problem and you don't know what the answer is, or if there is an answer, or if you're actually going to get to that answer" (Victoria, EEE).

What was unclear was how explicitly this teaching goal was communicated to students.

In the Year 2 Mechanical Engineering Design week, the level of uncertainty is deliberately high, resulting in an experiential learning process for all, with authentic problem-solving and associated emotions. Kris was clear that an alternative project design would be easier, but less transformative:

“we can completely circumvent this by doing the project ourself or repeating the project year after year...It's completely deliberate, I think, that...we haven't done the projects ourselves. We don't know what the correct answer is, and we're not pushing to a direction. And yes, it's frustrating if they ask a question and we don't have an answer to it, and it's not really good for your ego” (Kris, ME).

Kris demonstrated awareness of the emotional challenge this creates for his teaching colleagues, especially those whose own identity goals may be closely linked to being knowledgeable, such as Ironman:

“[Ironman] might now be annoyed with me, but I indeed tell [students]...if your tutor gives you advice, it's perfectly fine to implement that, but you need to know why, so always ask your tutor, ‘Why is this the best way of doing it?’ And keep on asking why ‘til your tutor doesn't know!” (Kris, ME).

Kris was clear that tutors should not tell students what to do because the goal is that students manage the uncertainty themselves. This was uncomfortable for students and teachers who equate knowledge transfer and advice with supportive and competent teaching. Seen through an emotion as relational orientation lens (Parkinson, 2019), this can be explained as some tutors and students sharing an orientation to the objects of ‘knowledge’ and ‘teaching’ that Kris did not share and this resulted in converging and diverging emotions. From the student perspective, this was interpreted in several ways. Some student responses conveyed frustration at their tutor’s lack of willingness to help by giving clear answers, for example “vague answers to problems increase stress” (Student157, ME). Other student responses demonstrated that they understood the goal was to learn how to deal with uncertainty inherent in getting to an undefined answer, their need to ask questions and the role of the teacher in this: “Our design tutor is very knowledgeable and so we often ask him any questions we have regarding how this may be done. This allows us to feel confident that there is an answer out there” (S171, ME). Although Student171 indicated still valuing their tutor being knowledgeable, this seemed to relate to ‘contextual knowing’ and ‘procedural knowledge’ (‘how this may be done’), and support for their own discovery of

knowledge, rather than expecting a factual answer. Through their reflection, I suggest that Student171 demonstrated 'metacognitive knowledge' and a broadening in understanding different types of knowledge beyond one correct source of 'factual or conceptual knowledge' (Krathwohl, 2002). This knowledge-related goal also seemed balanced by recognition of a more affective goal, around building confidence and an openness to the need for learners to discover an answer. Student156's response, below, represented those still in the process of learning to accept this shift towards independence and away from tutors giving advice:

"The teachers are able to help overcome [nerves] but do not help in terms of giving advice. He is a nice chap, he can become frustrating but...he is this way to serve as a learning opportunity, as he wants to replicate what real Life is like" (S156, ME).

Student156 seems to recognise how such interactions led to construction of contradictory emotions, as teacher and learner goals become aligned. They seem able to separate a negatively valenced emotional interaction from the supportive relationship.

However, when looking at student survey data, Kris was disappointed that some students suggested that their tutor was not supportive. I attempted to reorientate him by pointing out that within this emotion-based data, negative responses could be interpreted as students having misaligned expectations of their tutor, to which he reflected: "That's a good shout, that's basically a student who hasn't paid attention to the brief" (Kris, ME).

Barnett (1999) argued that universities have a role to play in helping society deal with epistemological supercomplexity, knowledge mayhem and living amongst uncertainty. As I have illustrated, to some extent, learning to work with uncertainty is being reflected in UG STEM curricula and this influences learners' and teachers' emotional interactions. Feelings of uncertainty have different meanings in different STEM disciplines and professions, and how this meaning is negotiated and reflected in preparation for professional life also influences emotion. All UK final year medical students sit a Situational Judgement Test (SJT) used by the UK Foundation Programme (UKFP) to stratify their applications for first graduate jobs. This high weighted assessment is designed to specifically assess professional attributes. Candidates choose a single best answer (SBA) from ranking-style questions that each present a professional dilemma. In recognition of the challenges involved in teaching UGs how to approach clinical uncertainty, and assessing it via the SJT, Ismail and Patel (2019) noted that less than half of an expert group could agree on an SBA for 23% of the test. Antonia explained how teachers had integrated this style of clinical thinking into the Year 1 and 2 medical curriculum "at really quite an early stage, and I think

it's helping, because there is this sense of "Oh my, so why is that a better option. They're none of them ideal, but which is the better amongst this lot?" (Antonia, MD).

Where the context was judged to be high stakes, like the summatively assessed TBL for Year 1 medical students, uncertainty could be a source of tension between students and teachers:

"they can get quite tetchy... we asked a question recently around ECG, and we scaffolded that question really well and then asked them about a condition they hadn't heard of before. But the condition was irrelevant. They could get the answer from the scaffolding. But they all obsessed on this condition they hadn't been taught. And said, 'It's not fair. You're, you're asking us questions around things we haven't been taught'. Well that's not the point. So, assessment, whenever the assessment's involved, they're always going to get horribly stressed" (James, MD).

Teachers described addressing the tension created by uncertainty in a number of ways. As William and Kris, colleagues in Mechanical Engineering, explain this included explicitly highlighting the value of this transformative learning for achieving both longer term academic and professional goals:

William: "this is the first time a lot of these students are doing this. It's, we're aware that they struggle with it, but because it's so important to engineering, we have to push through that pain. And I think that the sooner they get through that pain, the better they do later, and then, of course, once they go out into the real world, they've got all this experience they can talk about...Do you, do you point out how useful this will be an interview in a future career, Kris?"

Kris: "I actually have a big thing in my first lecture where I say, well, whenever you start working, your boss will never ask you to do an exam... They will give you a task and they ask you to deliver something...without giving you a template. This is what I expect. And I tell them that's why I'm not giving you a template for a report. That's why I'm not telling you, I'm not giving you examples."

This conversation is one of many that involved teachers becoming aware of how each built emotional competency through the curriculum and, I suggest, identified greater potential for this. I consider it an important finding that teachers demonstrated keenness and ability to

talk about emotion in STEMM education in this way and that these conversations did not seem to have occurred previously, independently of this research.

6.6 Overcoming discomfort of not knowing

Teachers' and students' responses indicated that clarity of knowledge-related goals, in the face of knowledge-related disorientation, could support important cognitive and emotional development. They also revealed a mismatch in knowledge-related goals that contributed to challenges in overcoming discomfort around not knowing, or not already having the required knowledge or competence. Influencing factors included knowledge-related beliefs and social norms between students, that, to the annoyance of some teachers, like Ina, sometimes seem counterintuitive in light of overarching HE goals: "That's quite annoying actually. We know you're incompetent. That's why you're there. You're there to learn. And my job is there to teach you...I wish they didn't think like that" (Ina, CH).

This was significant enough of an issue that Vivek, a clinical tutor less embedded within departmental culture, queried this apparent student perspective with fellow teachers: "If you know all the answers, why do you need a tutor teaching you? I don't know if you guys agree with that. I think I might be slightly controversial" (Vivek, MD).

As Ina had experienced, setting an expectation and offering help in Year 1 labs was not enough:

"One of the most annoying things, actually, [laughs] you hear a little group of students telling each other that they don't know what to do. So "Do you know what to do?" "No, I don't know what to do." "Do you know what to do?" "No, I don't know what to do." And then they do this little giggle. "Nobody knows what to do." And you're standing right there and you would help them... You go up to them and ask them, "Do you need some help?" Some of them that will say 'yes', sometimes even still, they say 'no'" (Ina, CH).

Ina's annoyance, she explained, is because she does not expect students to know and feels that her goal to help is explicit. Although Ina, unsurprisingly, did not recognise it, this peer conversation may be an important example of emotion socialisation, that could be enhanced by encouraging students to talk about their fear of looking like they don't know (Ippolito and Kingsbury, 2024).

As Clare explained, in Life Sciences, lack of high-level competence in maths is not unusual and could be perceived by students arriving in that culture as reassuring or daunting, depending on how it is handled:

“there's maths phobia in biology...A lot of the department academics don't have fantastic stats skills or fantastic maths skills and almost don't hide that. And I think it's quite unnerving knowing that you're learning something that, you know, maybe your personal tutor actually doesn't really know (Clare, LS).

Clare also suggested that modelling ‘not knowing’ needs to be an explicit, sign-posted strategy if it is to support students in making more accurate attributions and appraisals, in turn helping to manage their emotions:

“I don't enjoy maths...the only approach that I've kind of felt confident taking with this is to be completely honest. And say, ‘I'm not a mathematician. And I, you know, I'm very much in the same boat as you. And we'll work through this stuff together.’ And I think they, I think they appreciate it. And it's partly because it's self-evident when I can't answer their questions that I don't know what I'm talking about” (Clare, LS).

That this is ‘self-evident’ or authentic is important. Her colleague, Andrea, queried whether students believe teachers, and how much teachers can really influence emotion through reassurances, saying:

“Statistics is something that comes with time and you will build up your expertise. But that doesn't stop the ‘here and now discomfort’ that they, that they're going through at that moment, does it?” (Andrea, LS).

What Andrea went on to illustrate is how this might be more authentically done when team teaching demonstrates how distributed cognition works in professional practice:

“I think it also helps in breaking down those barriers between the staff who are meant to be the experts and know everything and the students who don't... And when you try and say to them ‘Well, look I didn't get this first time.’ But you know, sometimes I think hmmm, do they believe us? But I think when you actually demonstrate, they are going to believe you. (laughs) Ahh and it's like, ‘Alex, can you come over here? Because I just cannot suss it.’...But then they quickly don't bother asking me and go straight to Alex!” (Andrea, LS).

Again, it is evident that this modelling strategy is not without risk to reputation for Andrea. Despite its value, another limitation of modelling is that ultimately teachers are not in the same boat as their students; their future no longer depends on the same measures of knowledge, such as exams, nor is it generally across the same breadth of knowledge. As Clare observed:

“in a lot of ways, we're asking the students to be generalists, in their degree. To do a bit of everything and be quite good at a bit of everything. And actually, most of us are not really generalists. Like we're quite specialised in what we do. And I don't think they often kind of reflect on the fact that Alex is great at statistics but not so good at cell biology and Clare's good at cell biology but really can't do statistics. So having that conversation I think is important” (Clare, LS).

I suggest that the conversations between students and teachers that Clare advocated for are important for emotion socialisation relating to learning to cope with discomfort of not knowing. However, James and Kris highlighted more structural aspects of curriculum design that need to be addressed if students are to overcome fear and threat responses to looking like they do not know, and their relationships with knowledge and associated emotions are to change.

“Medicine is overwhelming and that's our fault... It's not an Imperial problem, it's worldwide, but medicine is a vast subject. You need to teach them so much. How do you narrow that down so you're not overwhelming them with material?...I guess from our end, you know, it's not overwhelming for us, but it's a lot of work for us. And therefore, I'm not sure our focus is quite enough on what other people are doing...Are we still over burdening them with content? (James, MD).

Here, I suggest that James referred to how delivery of a content-heavy curriculum could lead to a lack of oversight by teachers and awareness of what experiencing this curriculum felt like to students. Meanwhile, Kris questioned the negative impact of assessment approaches on students' knowledge-related beliefs and practices:

“Too often our criticism of our students is that they do it for grades. So we give them a task and...their question is not, “How do I do this best?” but their question is, “How do I get an A star for this?” (Kris, ME).

In my experience, this is because assessments are generally approached and understood as a proxy for measuring what students know, rather than inspiring new ways of knowing.

Clare expressed surprise at the extent to which her students seem concerned about risking “looking stupid” and how this fear of being perceived as unknowledgeable created an emotional burden that could unhelpfully increase cognitive load:

“something I was quite shocked at is that they really have a fear of looking stupid...like, it's not just a fear of not being able to manage the subject matter or the content. It's a fear of not being able to manage it in front of academics or teacher or peers” (Clare, LS).

Not knowing or understanding was not perceived as a concern by all students. As Student27 explained, not knowing why “stuff kept happening” created a motivation to learn why:

“Makes me want to learn - loads of stuff kept happening that I didn't know why (noise signal degradation effects like that) and I want to learn why they're happening so I know how to expect them and get rid of them” (Student27, EEE).

In terms of factors that contributed to this, as EEE teachers anticipated, Student27 also recognised that “Teaching helped provide enough knowledge to have the initial satisfaction.” Given the Year 1 EEE project redesign, maybe Student27 also felt that they had time and space for trial and error. This resonates with connections made between Piaget’s conception of learning by accommodation and updating of cognitive schema, and the emotion-related instinct to want to make more accurate predictions (Huberman and Immordino-Yang, 2023). Simon observed that in Chemistry labs, students seemed to overcome their fears of getting it wrong when they had chance to repeat and practice, building self-efficacy through these mastery experiences (Bandura, 1994).

Although overall it was judged to be a positive learning experience, Design Week, where mechanical engineering students collaborate on authentic and unpredictable assessed project work to a tight schedule, could mean that students felt they needed to work to existing strengths and therefore not take risks that would help them to develop:

“We have a good dynamic, each person has their own strengths and we can really make use of that in an accelerated design week. Although it's a little sad also because we are always trying to work in our comfort zones. So we don't really get a chance to do things we are bad at because otherwise it will be a big waste of time” (Student183, ME).

This could be compounded when an individual's physical and mental energy reserves ran low, leaving little capacity for resourcefulness when "things keep going wrong":

"Extremely tired and stressed. Unhappy. A lot of things to think about with vague guidance creates a lot of stress. Extremely deactivating as it is extremely demotivating when things keep going wrong" (Student157, ME).

To counteract the fear of things going wrong and not understanding, many students referred to the benefits of peer support as their relationship with knowledge developed and they learned to cope with associated discomfort together:

"It made me feel a bit scared before attending class but during the session I felt reassured... My peers also contributed to this feeling to a large extent as talking with them and working through the problems together made me feel united as they also did not understand some of the content initially and it made me feel less alone" (Student66, LS).

Teachers recognised specific instances in their curricula where students were concerned about getting it wrong and how this might be related to the type of knowledge and the shift in epistemic beliefs required. An example was medical students moving between learning anatomical science to more ethical aspects, as Jessica explains:

"sometimes it can be quite difficult to get students to engage in discussion because it's a difficult topic, because they feel like there's not a right answer, which they've been kind of used to in other kinds of teaching" (Jessica, MD).

Clare talked about how she deliberately led students to make mistakes in order to reinforce important learning through experiential learning. She described scaffolding and being explicit about the educational goal. She, herself, was reassured about this potentially risky strategy by feedback from students who seemed to understand and appreciate her teaching goals. In this way she managed to balance challenge alongside safety:

"I definitely have lectures with my first years where I basically make them fall into the common misconceptions on purpose. So they all get the Mentimeter [e-voting questions] wrong and that's as intended because that's what everybody does...And then we spend time explaining what was the purpose of that. 'I expected you to get it wrong'. And the act of, if I just said to them, 'oh, everybody thinks it's this, but actually, it's this', I think it

doesn't go in but when you kind of fall into the hole yourself that's more of a learning experience that you remember" (Clare, LS).

It was not clear whether Clare was aware that part of this experiential learning and memory updating involved processing emotions (Immordino-Yang, 2016), including those associated with making common disciplinary mistakes.

6.7 'Controlling' knowledge in active learning

Central to my rationale for selecting case studies of modules that involved active learning, was that active learning is designed to engage students emotionally as well as cognitively, (Marshall et al., 2014). This makes social construction of emotion especially salient. Teacher and student data suggested that this was the case, with a key factor being the sense of control and competency, or otherwise, that being able to check students' understanding of knowledge during active learning sessions afforded. This could contribute to social constructions of both positive and negative emotion, as Vivek observed: "active learning forces them to confront what they know, or what they don't know, much more immediately, than, kind of sitting in lectures does" (Vivek, MD). Sanjay explained that some student anxiety came from wanting more control over content knowledge than active learning allows, especially in a culture where access to captured knowledge from lectures is highly valued:

"they also have to take down notes, listen at the same time, participate at the same time. And because they're multitasking it is difficult for them to capture everything. And they would prefer sort of some way for them to revisit the live session" (Sanjay, MD).

Active learning also represents a considerable shift in control for teaching staff that can also result in difficult emotions, including frustration and anxiety, as they are reliant on students to cooperate and engage. Hubert articulated his construction of this emotion, that might reflect a shift in control from teaching design to student engagement:

"maybe it's not even anxiety, whether it will work out or not. It's more, it's even an anxiety whether...the students will, you know, actually engage with it or whether it will, it will, you know, not to be a total disaster" (Hubert, CH).

This could be compounded when teachers felt instructions and rationale had been made explicit and lack of student engagement got in the way of unique and complex teaching goals, such as those achieved through fieldwork:

“I get the most frustrated when you're asking students to do something for a reason, you know, read this, do this, whatever, because you need that knowledge in order for us to do the next thing and when they don't come with that. Especially when it was going [on a field trip]” (Andrea, LS).

Focus group interviews revealed teachers' approaches to developing pedagogic knowledge for designing and facilitating impactful active learning, alongside learning to cope with, or mitigate against associated negative emotions. Teachers indicated that in active learning settings they are balancing student peers' goals and emotions, as well as their own. Weighing up whether they needed to take action involved considering the motivations, needs, preferences and emotions of all parties, whilst being inclusive. Here Sophie evaluates the impact of a student's lack of active engagement:

“he's starting to really like annoy me...he has these huge headphones on and he wears them, like, all the time...With seminars, because they're not assessed, if he's not bringing the rest of the group down...I'm not going to pressure someone to, like, get involved in it. Because that's their own loss, really...I had a chat with him about it in the lab last week. And he's like, 'Oh, I'm a theorist, so I don't like doing stuff like this. I just like doing maths' (laughs)” (Sophie, PH).

Some student responses indicated the negative impact to peers when some control of a session's value was given to students who didn't share or contribute to active learning goals: “Happy but also slightly bored. Some of my seminar mates do not respond too well to the teaching style of the seminars” (Student265, PH).

Andrea expressed some concern over active learning approaches:

“I'm going to say boredom because sometimes we overdo it, I think. There's too much active learning stuff, maybe for active learning sake...And it's like, 'Well, you've spent three quarters of the session asking three questions and waiting for Mentimeter responses...what sort of knowledge have I come away with?' so I think they can get a little bored” (Andrea, LS).

This seems not to acknowledge valuable cognitive and emotional processing that the 'waiting' time may facilitate, nor alternative active approaches. It is possible that this was based on Andrea's own discomfort with sharing control and reducing time for valuable knowledge delivery, in line with disciplinary, her own and/or perceived, or real, student expectations. Other teachers reported particularly enjoying the advantages new active learning approaches bring, as they strongly align to their educational goals, in George's case around interaction and attendance:

"recording allows you to really free a lot of time, right?...Students can watch it at home, and then you can spend 100% of your time interacting with students. And what I like specifically of TBL...is that it gives me 100% attendance" (George, EEE).

Others felt frustration due to lack of control, in Alex's case over cohort sizes that block his goal to more fully constructively align assessment methods with active learning methods:

"in an ideal world, I would, I would assess the module totally differently, but I have 300 and odd students and... I can't get them to do mini-projects. And that's quite frustrating for me because I feel like if they got to...go out and find their own data and...even use data that they are more interested in" (Alex, LS).

6.8 Working with epistemic emotions

When asked what emotion teachers would like to inspire in students, the overwhelmingly most common response was curiosity. Curiosity is one of the epistemic emotions that are categorised and judged by Pekrun et al. (2017) as being valuable for learning, but potentially uncomfortable. Epistemic emotions - curiosity, surprise, enjoyment, confusion, frustration and anxiety - result from an individual's appraisal of the extent to which incoming input aligns with their "cognitive characteristics, including prior knowledge, epistemic beliefs, and epistemic aims" (Muis et al., 2021, p4). Under this sub-theme, I consider the ways that teacher and student data gave insights into how epistemic emotions are socially constructed in these STEMM learning settings.

6.8.1 Constructions of curiosity

Curiosity, and its perceived value, were often linked to desirable learning behaviours and relationships with knowledge that were considered important during the degree and in professional life. Curiosity can be defined as "a desire for information in the absence of

extrinsic reward” (Markey and Loewenstein, 2014, p228). Linked to this, the *information gap theory* explains our motivation to close a gap between what we know and want to know (Loewenstein, 1994). This can depend on importance of the information to us, degree to which our environment highlights a gap and our surprise about a discrepancy, when our beliefs are challenged (Markey and Loewenstein, 2014).

As well as observation, it was the nature of students’ questions that teachers mentioned as signalling their levels of curiosity. From a student perspective, like other emotions, curiosity was experienced as mixed with other feelings, often changing as appraisals of how successfully they were doing in achieving goals fluctuated:

“Depends on the moment, sometimes it makes me curious and other i just want to go to bed and cry” (Student156, ME).

“Lot of interesting feelings were felt during the group project. Firstly felt a bit overwhelmed, then really curious and excited to know seeing the real world applications of the knowledge we learnt in first year” (Student42, EEE).

Teachers, including Tariq, recognised this mixed emotion too:

“I’m just thinking about the start of the project. So that is the stage where I think they’re most anxious as well. They’re very curious as well, because that is the stage where they know what are the expectations from them for getting a final product. And they know little about how they can achieve this. So they are trying to find out a way they can move forward” (Tariq, EEE).

The anxiety Tariq inferred may be epistemic anxiety that is experienced when individuals feel uncertainty about knowledge beliefs that are core to their identity and feel that, in this way, their identity is threatened (Muis et al., 2021). It makes sense that Taariq’s students experienced this at the point they were made aware of the goal, but did not yet know how to achieve it. Anxiety can increase extrinsic motivation to invest effort in complex cognitive processes, such as analytical thinking, to avoid goal-related failure (Muis et al., 2021) and it may be that, in combination with intrinsically motivated curiosity, time and space this supports goal achievement.

Teachers were readily able to identify what they thought stimulated and sustained student curiosity and what prevented it. As Pekrun’s (2006) CVT suggests, this was strongly linked to perceived value and control of the information, or its application. Barriers included an

unwillingness to experiment, lack of conceptual understanding on which to build and variation in understanding and ability, the last of which Brian illustrates:

“we get this big gap with technical ability of students who’ve done electronics at home. I think in that case, you know, they’re not going to be made curious by this module...at the other end of the spectrum, those who’ve fallen behind, then they’re not going to be curious just because none of what’s happening is meaningful to them” (Brian, EEE).

Some teachers discussed the negative impact of assessment on curiosity, as William indicates:

“I think we’d reward curiosity more if we didn’t mark it. Because that’s the thing that Kris was saying knocks the curiosity out of the education system where, you know, in order to get the marks, you have to do this, this and this” (William, ME).

Whilst individual teachers have significant control over ways that they can promote curiosity through teaching and learning activities, a sticking point and source of frustration can be summative assessment where individual teachers (and students) have less control and epistemic beliefs can be entrenched and influential. Alex’s example suggests that possibilities may lie in more open-mindedness and creativity in recognising constructions of curiosity in students’ assessed work:

“I think we’re afraid to give them too much control...As a first examiner, if they only spoke about nitrogen fixation, I was like, great, they can still get an 80. But then my second examiner was like, ‘Oh, no, but they’ve completely missed out this’. And I was like, in my head, well, I think, personally, they’re more curious about understanding that more...and they did more outside reading about it...I personally think is really great when we can reward them for being creative. And I don’t think we do that enough” (Alex, LS).

Conversely, Kris was confident that curiosity could be rewarded in assessment outcomes: “With Design in particular, if you can get them curious, they’ll do better” (Kris, ME).

Participating teachers seemed most keen to construct interest-type curiosity, linked to a pleasant desire to know, rather than deprivation-type curiosity (Litman, 2008). Examples given by teachers framed students’ curiosity as related to interest in specific and varied topics, with, for example, anticipated and observed preferences in ecology spanning

terrestrial, marine-based or river, big organisms or small organisms. Curiosity also related to students' interest in their own development, revealed through formative assessment: "I think the students quite enjoy testing themselves. And like figuring out whether...on an individual level, has it gone in? (Clare, LS). Teachers' responses suggested that curiosity was socially constructed between learners and teachers based on a combination of conditions. As James explained, this could be a delicate balance that required planning, but also space for spontaneity:

"they're not necessarily assessment focused, they're just in the moment, talking about a particular topic...they are just genuinely really interested, and they want more detail, and they can see that there's enough expertise in the room that they're going to get some good answers" (James, MD).

Simon suggested that the opportunity to exercise curiosity through choice might have a value of its own, in this case contributing to reward in the form of another pleasant emotion (Atkinson, 1957), such as pride:

"There's a greater level of ownership and control that the students then feel relating to the piece of work. And so I think that really feeds into this, especially when it's kind of open ended, that kind of curiosity that can kind of then further that sense of pride in your work" (Simon, CH).

Like teachers talked about recognising curiosity amongst students, several students reported recognising curiosity in their teachers. In this case, Student172's inference might reflect the discrepancy they perceived between the goal and time allowed: "[Teachers feel] Curious, I assume they wonder how we will do as they know it's not an ideal time frame" (ME 172). Student54's observations may indicate recognition of alignment in learners' and teachers' goals and outcomes, where both are aiming for creativity: "[Teachers feel] Curious to see innovative solutions" (Student54, EEE). Whereas Student54 indicates the possibility of emotional convergence felt when people's orientations towards events or objects align (Parkinson, 2019), Ina highlights that the opposite is possible: "Maybe they're just curious, but not about the things that I would like them to be curious about" (Ina, CH).

The differences in constructions of curiosity that the data revealed, may explain why it can be difficult for teachers to recognise student curiosity and highlights the challenges for developing emotionally-informed pedagogy. This is especially the case when learners' relationships with knowledge, including what inspires curiosity are different to their teachers or their teachers' curiosity preferences for students. Hubert's quote captures the interacting nature of emotions that also makes this balance, echoing Folkman's (2013) assertion that

emotions that attract our attention, including unpleasant ones, relate to situations of personal significance: “What you want is the perfect combination. Because the things that get them curious are also things that cause them to be anxious” (Hubert, CH).

6.8.2 Constructions of confusion

Empirically-based theory suggests that “confusion arises from a cognitive appraisal of a mismatch between incoming information and existing knowledge” (D’Mello and Graesser, 2014, p291). This process involves a learner trying to determine how new information fits with their existing cognitive schema, ascertaining that it doesn’t fit and accepting a need to adjust mental schema to accommodate it (Cavanagh, 2016). Barriers to learning can occur when an individual perceives the source of confusion to be novel and complex information that goes beyond their understanding (Muis et al., 2021). Confusion can also be experienced in response to inconsistencies or disruption to goal achievement (Graesser and D’Mello, 2012) as Victoria recognised amongst her students: “many times students were confused why things are not working...actually why what they achieved does not match what they expect to achieve” (Victoria, EEE).

In their questionnaire responses, students very rarely referred to confusion. Maybe, for them, it was common, accepted and therefore a less noteworthy feature in STEMM learning. When they did, their responses implied that confusion had an activating effect, prompting collaboration that supported both cognition and emotional regulation: “Helps us to call out to each other when we are confused and need to think about what work to do” (Student176, ME). Teachers did not refer directly to being confused either and their own epistemic emotion was much more likely to be labelled as frustration. This may be because confusion is often alleviated quickly and by the interview stage teachers had resolved any confusion over difficulties in achieving teaching goals, through finding an explanation, identifying a strategy and/or accepting that it was an inevitable part of the process.

Teachers agreed that confusion was an inevitable or even important part of the learning process. As D’Mello et al. (2014) recognise, confusion can create a cognitive ‘jolt’ that focuses attention on correcting a discrepancy and can lead to deep learning. For Kris, this formed an important goal:

“we need to confuse our students every hour, particularly in Design. So they need to think outside of...their normal way of thinking and solutions. And being confused is a good one in there. And I think we do that by indeed, making sure that we give them a brief that is completely open and

not very clear. We don't specify exactly what we expect from them" (Kris, ME).

In an educational context where transparency is required and a central tenet in inclusive practice, this can be a tricky line to tread and later Kris was keen to clarify that the brief was clear but involved uncertainty. A number of his students criticised the "lack of clear instructions" but overall they reported that the experience felt engaging and activating, suggesting a brief temporal, and possibly cognitively stimulating, effect of confusion.

D'Mello and Graesser (2014) explored the temporal dynamics of confusion and identified a 'zone of optimal confusion' when the discrepancy is severe enough that it exceeds a threshold for confusion to be experienced, but not so much that the individual becomes flustered. Furthermore, that its duration is long enough for an individual to try to resolve the confusion by identifying the discrepancy, but not become frustrated or bored. There was some difference of opinion between teachers over the 'use' of confusion in educational design which D'Mello and Graesser's (2014) temporal dynamics ideas helps to interpret. Unlike other teachers, the Physics teacher trio initially expressed less positivity about the value of confusion, although they acknowledged it was inherent, and new pedagogic approaches were described as designed to give students respite from confusion:

"But with the seminars...we tend to veto things where we think right, that's going to just confuse a tranche of the cohort (laughs). So, you know, let's try and actually pick something which is going to be more fun for people to do, where it's, where it's going to be a challenge, but they're not going to be confused" (Hemal, PH).

Although unarticulated, Hemal may have judged that cognitive load created by confusing content risks leaving no cognitive capacity for managing the emotional and social load that is a key aim of the more collaborative seminars. Later in the Physics teacher focus group interview, once the activation potential of confusion had been discussed, the educational value of confusion was recognised, but its controlled duration became important:

"Yeah, I love to have a student confused in the middle of activity. But at the end of activity, especially when they leave the seminar, I don't want them to leave the seminar confused, no" (Hamza, PH).

In this Physics cohort, students' only reference to confusion was that: "Collaborating and feeling just as confused about certain parts as others is really comforting" (Student275, PH). This could suggest that teachers have achieved their goal of resolving confusion by the

seminar close and maybe, in a curriculum where teachers and students recognise confusion being a prominent feature, a safe seminar space to resolve confusion is important.

Given the diversity within STEMM UG cohorts, it can be very difficult to predict what will give rise to productive epistemic emotions in all students. Student247 suggested “I think it would sometimes be more engaging to have a problem past the syllabus for us to puzzle over, at least at the end” (Student247, Physics). This can be hampered further by aspects of the curriculum that attract attention and effort, or not, due to perceived value and reward, as Hemal’s response to Student247’s comment highlights: “what it means is they’re not going into some of the open-ended problems as deeply as they might do, because, because they don’t have to do them” (Hemal, PH).

Teachers anticipated and observed students going through a series of epistemic emotions. As Brian’s quote reflects, they often made sense of this process through the lens their own experience and saw it as necessary for working in their discipline. Brian expressed the belief that students should learn to consciously control how they work through epistemic emotions, as this impacts outcomes. His response also implied that he expected this process to be challenging and that it was his role to support students with this:

“At this point where they try something, it doesn’t work, you know, it starts with curiosity, ‘why doesn’t it work?’ Then frustration, ‘why doesn’t it still work?’ And if at any stage they fix the problem, then, then we get satisfaction. Otherwise, if it doesn’t, it’s going to descend, I guess into hopelessness and boredom, you know, that’s the sort of problem we’ve got. But that’s the nature of all their project work, anyone’s project work... And that’s what we want them to think about. And then what do they do at that point? I’m projecting a bit about, you know, what I go through myself when I’m solving problems...It depends on the student how they deal with these themselves. But, you know, what we’d like to do is to attack all of these minor problems in a positive way” (Brian, EEE).

6.8.3 Constructions of frustration

Teachers frequently referred to students’ and their own frustration, as already indicated, and how it could have both an activating and deactivating effect. This can partly be explained by Pekrun et al.’s (2002) description of frustration as a combination of anger and disappointment, experienced as activating when it’s nearer to anger, or deactivating when nearer to disappointment. Frustration is an achievement emotion as well as an epistemic

emotion which perhaps explains its prevalence in a setting where both developing knowledge and achieving educational goals are of such importance. Some teachers observed that frustration seemed less activating towards the end of the project, when time to achieve goals was short.

The Physics teacher trio's interesting dialogue, based on the focus group interview Activity 2 (assigning emotional valence and activation - see Figure 4.2, p77), offered insight into their social construction of meaning around whether frustration is activating or deactivating for learning and what contributed to this:

Sophie: Ah frustration, How about frustration? Um negative and deactivating. Um negative and activating? Oh, I'm not sure.

Hamza: I think you start activating.

Sophie: Sometimes if you're having difficulty with a problem, you're just like, "arghhh I want to solve this!"

Hemal: Yeah, I guess it depends on the nature of the frustration. If it's...a problem sheet problem, where, and you've got faith in the lecturer or...you know that it's been designed in order to help you learn then and then the frustration can be activating, I guess...If it's frustration with laboratory equipment, that doesn't work then and you can't repair it, then I think that could be deactivating.

Sophie: Yeah, for me, I'd put it in activating. Um.

Hamza: I could see that frustration in online lab last year, especially the first couple of weeks, when a student didn't have enough help. They couldn't manage the, er, er setup that they had. But after a while, when they could solve the problem. They had a very good understanding. But I think the frustration itself is, I think the frustration itself is not activating, then I'm not sure, maybe I'm missing something here.

Hemal: If ever I was learning something, I'd be amazed if there wasn't at some point, I'd be frustrated with the learning process. So...

Hamza: Yeah, that's definitely true. We all have always had that feeling. But is it activating us or not?

Again, teachers moved interchangeably between their own and learners' observed and inferred experiences, seemingly concluding that frustration is inevitable but can be more activating if individuals feel a sense of control, specifically that they trust the teacher, task or equipment to support their learning. It is likely that this control-related frustration is mirrored by teachers, whose goal is to support learning. Teachers' deliberations may relate to whether they thought the emotional demand of frustration got in the way of specific cognition (gaining good understanding of a specific problem) but was necessary for broader cognitive development (learning to accept uncertainty in Physics problem design and lab equipment set up). Through talking about this, apparently for the first time, they identified different objects around which frustration occurs and influences each other's orientations (Parkinson, 2019).

6.9 Scaffolding cognitive and emotional load

Whether they were aware of cognitive load theory or not, it was common for teacher participants to construct meaning around working with students' and their own emotion in relation to pedagogic practices that could help manage cognitive load. According to theory, this involves scaffolding intrinsic load by breaking down complex concepts and tasks into manageable chunks, removing unnecessary extraneous load and optimising germane load by, for example, making learners more conscious of metacognitive processes such as actively building mental schema (van Merriënboer and Sweller, 2010). Plass and Kalyuga (2019) identify four ways that emotion in learning can be related. These include:

- viewing emotion as extraneous cognitive load, competing for limited working memory resource;
- the way positive and negative affect advantageously and disadvantageously impact on memory processes;
- emotion contributing to intrinsic load when it forms learning outcomes;
- impact of emotion on intrinsic and extrinsic motivation and cognitive effort, which may not be as straightforwardly associated with positive and negative emotion as expected.

This 'Knowing' chapter has illustrated how, in demanding STEM learning environments, cognition and emotion continually interact. This can partially be explained, in the seven modules under consideration, by the high interactivity of concepts that increases intrinsic load (van Merriënboer & Sweller, 2010). This includes through processing integrated scientific and clinical knowledge, theoretical and applied engineering knowledge, or

conceptual and procedural knowledge in natural science labs, as well as balancing processing disciplinary knowledge with peer collaboration. Additionally, although not officially articulated in programme and module specifications, as teachers have indicated, stimulating emotion is clearly a teaching goal across these STEMM modules and is therefore a learning outcome that contributes to intrinsic load. Student235, a medical student for whom the affective dimension of learning was more explicit as a learning outcome, illustrated the challenge that interactions between complex cognitive and emotional inputs present: “Confused, I only understood the science when it was explained in layman’s terms and even then to a limited level. Also a bit upset because the patient’s story is very similar to my grandma’s” (Student235, MD).

Teachers in this study demonstrated varying awareness of the ways in which emotion and cognitive load interacted and what could be done to optimise this in a way that supported important learning. This included scaffolding intrinsic load to remove unnecessary cognitive and emotional load, as described by Alex, in relation to teaching statistics and R programming :

“we use the same dataset throughout the whole course and even for the final tasks...that’s one kind of aspect that I can remove...They have an obsession, not obsession. They try to, if you give them new data, they will try and figure out what every single column means” (Alex, LS).

As Hubert reflected towards the end of our focus group interview conversation, in future he planned to:

“be a little bit more explicit in the guidance we’re giving...make them less frustrated and less anxious about what they are actually supposed to do. And that way they could, you know, focus more on actually thinking about *what* they’re doing, rather than *how* to do it” (Hubert, CH).

In this way he planned to reduce extraneous cognitive load, created by lack of clarity, that he observed to provoke an unnecessary cognitive load of negative emotion and free up cognitive capacity for intrinsic and germane load (van Merriënboer & Sweller, 2010).

Victoria described explaining to students:

“when you try things out for the first time, they probably won’t work, and that it’s okay to fail, because that’s how you learn. That if you do something and it goes perfectly well, you probably won’t remember it. But if you try

something and it doesn't go your way, and you're forced to sit and reflect and think about it, then you will remember that (Victoria, EEE).

In this way, I suggest she attempted to increase germane load by highlighting the value of the metacognitive process of reflection, especially for processing negative emotion, in a way that supports cognitive processes, such as memory formation and updating (Vogel and Schwabe, 2016).

Students' data also gave insight into students' perceptions of how cognitive and emotional dimensions contribute to achievement of their learning goals and the role that peers play in this process. Table 6.1 illustrates the ways in which Year 1 medical students, in a module designed for learning how to integrate scientific knowledge to address clinical patient cases, demonstrated varying awareness of the interrelationships between cognition and emotion.

Medicine student responses to: "How do your student peers contribute to this feeling?"	Learning goals
"We help each other and fill the gaps in each other's knowledge" (Student223). "Allows ideas to bounce between so different perspectives can be understood" (Student202).	Cognition-focussed goals
" Interesting discussions , encourages me to engage more" (Student205). "Some will explain things and make me feel better " (Student217). "We engage in productive discussion and have fun whilst learning" (Student200).	Awareness of interaction between cognition and emotion-focussed goals
"They contribute thoughtfully and with sensitive wording" (Student201). " Safe to discuss ideas" (Student232). "They make me feel relieved because they are struggling too" (Student191).	Emotion-focussed goals

Table 6.1: Student awareness of interrelationships between cognition and emotion (Ippolito and Kingsbury, 2024)

"Some student responses emphasised the cognitive value that peer interactions held for them (first row) and others' responses focussed solely on the emotional value of their group's interaction (second row). The third row shows quotes that illustrate how some student responses recognised the way that cognitive and emotional dimensions interact through the collaborative learning process to support their learning, as well as their emotional wellbeing. [I have mapped] their responses to learning goals to illustrate that, despite emphasis on knowledge-based learning goals in the official curriculum, students

recognise how, as a group, they address their emotional goals and argue that this provides evidence of valuable emotion socialisation” (Ippolito and Kingsbury, 2024, p5).

6.10 Developing and sharing pedagogic knowledge

This chapter began with presenting data that demonstrates how STEMM UG students’ emotional experiences can be influenced by their shifting epistemic beliefs and cognitive goals. Emotion is constructed as they progress from absolute knowing, through transitional, independent and, possibly, contextual knowing. Data also indicated that teachers are developing their pedagogic knowledge in parallel, including knowledge about the role of emotion in learning, to which their participation in this research evidently contributed. Many teachers demonstrated operating at the contextual knowing level, that involves continually, actively gaining knowledge and applying it based on judgment and contextually appropriate evidence. Additionally, teachers referred to cooperating with colleagues and students with less advanced pedagogic knowledge, creating a need for teachers to regulate their own emotions. As George observed, his frustration related to a lack of common understanding of educational rationale between himself, students and colleagues, meaning less likelihood of shared goals: “So it's not they don't understand the instructions or the format. It's they don't understand *why* it happens that way” (George, EEE). Because his pedagogic goals were very clear and he seemed aware that lack of goal alignment can lead to negative emotion, George paid particular attention to preparing students cognitively and emotionally for the learning experience on his module:

“my first hour of lecture is explaining the method, the teaching method. Because I want to clarify very well, why I do it in this way. Every single aspect of the teaching method that I implement has a reason, right?”
(George, EEE).

When we discussed student data at the follow-up interview, Alex expressed bemusement that when some students considered how he felt in the teaching session, they did so in light of his competency regarding the technical knowledge being taught, rather than his pedagogic knowledge:

“What I thought was quite interesting about the first few were those that were kind of like "oh bored, because he's, he's good at this"...and I thought...that was quite funny, because it wasn't about my ability as a teacher...they linked it to my ability to programme or my ability to do statistics” (Alex, LS).

In a way it is not surprising that some students applied to Alex the same knowledge-related goals and resulting epistemic emotions as they set and experience themselves, for example, that if they know it, there is less emotion-based salience leading to cognitive stimulation so it becomes boring (Immordino-Yang et al., 2019). However, it does highlight how, although learner and teacher knowledge-related goals and associated emotions do converge, there are also many reasons why they diverge.

As a result of her participation in this research, and particularly considering the novel student emotion-based data, Ina began thinking about how this emotion in learning-related knowledge could be shared with colleagues and integrated into the Chemistry curriculum:

“That was what I thought when you asked, ‘What do you want to do as a result of this feedback?’. I don’t know whether to just show it to staff or to try and include it somewhere in [first year module to support academic transition] for the students. This idea that stress is not necessarily a negative thing could be a really powerful idea actually to get across. ‘I’m feeling stressed. Yes. Okay. But does that necessarily mean I feel bad, or I feel scared? Maybe it doesn’t need to’” (Ina, CH).

6.11 Chapter conclusion

In this chapter, I have demonstrated how STEMM students and teachers, across these seven case studies, reported experiencing and perceiving a range of differing emotions in pursuit of their knowledge-related goals. Data revealed that emotions were influenced by, and constructed through, students’ and teachers’ interactions, as together they tackled engagement with complex knowledge and development of understanding, and faced challenges to epistemic beliefs, goals and practices. The data presented demonstrates that most teacher and many student participants recognised that university learning involves changing relationships with STEMM disciplinary knowledge. This included what can be known by UGs and discipline-based professionals, how to cope with uncertainty, not knowing and making mistakes, and that these processes, involving engagement with knowledge, contribute to cognitive and emotional development. Student participants’ responses placed them a continuum in terms of managing knowledge and associated emotions. This extended from those who were able to appreciate, to balance and to consciously gain from the interaction of cognitive and emotional components, to those who felt overwhelmed by cognitive and emotional loads, including because it appeared to be impeding their knowledge-related goals. It is important to remember that this is a snapshot,

capturing learners' state and/or trait emotion at one point in time, but that some responses seemed to reflect wider learning experiences. Students' relationship with knowledge seemed to be influenced by peers and teachers, including their willingness to collaborate and to recognise other socialising agents' knowledge-related goals.

Teacher participants, to some extent, also demonstrated being on a continuum, in terms of their awareness of how knowing and feeling interact in their discipline, their ability to manage the discomfort of not knowing in themselves and their students, and their knowledge about how emotion, including epistemic emotion, functioned to support and impede learning. Teachers gave many of examples of ways they provide cognitive and emotional scaffolding to enable students to make this epistemic transition. It is evident from the data that teachers' and students' knowledge- and knowing-related emotional experiences continually interacted and influenced each other. In this way, emotion contributed to a continual negotiation and social construction of beliefs and goals around what it means to know in these STEMM HE contexts, including what knowledge is valued and to what extent one can feel in control of STEMM knowledge. In the next chapter, I consider the ways in which being evaluated influenced student and teacher emotions.

7. Evaluating: Social construction and appraisal of goal achievement

7.1 Chapter introduction

In the previous chapter, I presented findings that illustrated how gradually transforming epistemic goals and relationships with knowledge can influence emotion, as well as how the emotions experienced through teaching and learning interactions influenced cognition. In this chapter, I discuss a second over-arching theme developed from teacher and student data: how individuals' evaluations of learning and teaching achievements impact on their emotions and emotional interactions with others. I also use the data to critically consider how emotion influences the validity and usefulness of evaluation.

This chapter draws specifically on achievement goal theory and appraisal theories, including social appraisal and achievement emotion theory, to explore how, in challenging achievement contexts, individuals and groups construct their goals, evaluations and emotions based on socially constructed beliefs and practices regarding what is valued.

7.2 Evaluating yourself compared to others

“Student data indicated that participants' tendency to compare their ability and progress towards academic goals with peers contributed significantly to their emotional experiences, both positive and negative” (Ippolito and Kingsbury, 2024, p6). Some evidence of this was already presented when considering relationships with knowledge in the previous chapter. The phenomenon of comparing ourselves to others, including in relation to successful goal achievement, has been of interest in social psychology for many years. In 1954, Leon Festinger proposed ‘Social comparison theory’ to explain our tendency to compare ourselves to other people, based on an innate human drive to evaluate our abilities and opinions. In these challenging STEM learning contexts, social comparison functioned in complex and contradictory ways, as will be illustrated. In the context of this study, I argue that social comparison functioned as tool for social construction of meaning and emotion, in relation to academic goal achievement. Teacher data gave insight into their understanding of how these processes influence student emotion and behaviour, and how teachers perceive their role, including based on their own experiences.

Social comparison can be especially important at times of uncertainty, when it may be more relevant for an individual to judge whether they are performing at the expected standard (Kamarova et al., 2021). Furthermore, as Valiente et al. (2020) explain “[h]ighly academically motivated students may be more susceptible to peer influence toward improved academic functioning...because they similarly value achievement, making influence toward heightened levels of academic achievement more salient” (p10). This is very relevant to the highly academically selective university that this study focuses on. Social comparison tends to happen in one of two ways. We compare ourselves to those we think are better at the ability under focus than us - upward social comparison - or who we think are less able than us - downward social comparison (Burleson et al., 2005).

A number of teachers considered this transitional process, and associated emotional experience, to be inevitable, as students adjust to the environment and its demands, and acknowledged that it can be difficult, as William explains:

“you take a bunch of high achievers, and you put them in a stressful situation and they're not, they're no longer the big fish in the little pond. They're gonna get anxious. It's just how it works. It's how you manage that that makes the difference...what Kris is saying about how to deal with that [normalises the discomfort of confusion], I think is a good thing” (William, ME).

It is notable that he highlights the role for teachers in supporting this. Importantly, upward social comparison can lead to a favourable outcome of feeling inspired, as well as an unfavourable outcome of feelings of inferiority. Burleson et al. (2005) demonstrated that in an educational setting populated by highly capable others, like the one in this present study, the difference between those whose upward comparison led to feelings of inspiration, rather than intimidation, seemed to lie in interpretations of comparisons. Inspiring upward comparison was more likely when participants considered the other person to be similar to them in some way, and concluded that they could be successful like them. Conversely, upward social comparison leading to feelings of inferiority were more likely when individuals considered themselves dissimilar in a significant way and therefore unlikely to have their peers' success (Burleson et al., 2005). This is consistent with the assimilative and contrastive approach to social comparison (Heider, 1958). Although not the focus of this study's analysis, this has important implications for under-represented students.

7.2.1 Unhelpful social comparison

Student data indicated an interesting relationship between students' reported emotion and the function of comparison; they were more likely to refer to social comparison when describing feeling negative about their learning. However, as we can see from Student182's quote below, an unfavourable upward social comparison did not simplistically lead to purely unpleasant emotional experiences:

"Its quite fun. I enjoy working with my team although it feels quite stressful especially close to the deadline. I have a good team but I'm a very below average student (as proven by my grades) so it's very daunting and I have a history of anxiety so it can be very nerve-wracking... I don't feel like most are struggling as much as I am and since they're naturally better students, they have an easier time than I do" (Student182, ME).

A number of factors inform this student's appraisal and unfavourable upward comparison. Their use of the word 'proven' highlights the perceived definiteness of assessment results and their impact on self-concept, in comparison with other students' results. Their opening sentiment is that the teamworking is fun and enjoyable, and reflects many students' reports that peer interaction to some extent eased discomfort of academic pressure. On the surface, they appear to have a fixed mindset in terms of their theory of intelligence (Dweck, 2017) toward their own and other students' academic ability. It is also possible that their assumption that peers are having an 'easier time' is not based on evidence and is linked to fixed mindset beliefs, that peers are lucky to be clever. However, they also say that:

"I perform worse under stressful conditions and find [it] hard to focus on the task at hand. It usually returns with negative feedback even after hard work (example a bad grade) so not helpful sometimes...[I] Try to look after my mental health and stay on track as much as possible but sometimes I can feel anxious and worried even if there are no real causes for concern. I think they [the tutors] help a lot of people as I'm sure they do. It's just that his help feels very artificial sometimes and doesn't really work well with how I wanna learn" (Student182, ME).

Student182 begins by offering attributions for their 'failure' and exhibits a typical combination of "negative self-cognitions, negative affect and impaired performance" (Dweck and Leggett, 1988, p257). However, it seems unhelpfully simplistic to categorise this student as having a 'helpless', purely performance-focused orientation, as though this was their fault. There seems to be a misalignment between their learning goal and the tutor's approach that results in a lack of meaningful connection. The language they use to describe the feedback as

'negative' could mean they don't respond well to (constructive) criticism or that feedback is unsupportive in tone. They demonstrate awareness and agency regarding their mental health and the way it relates to emotion related to learning. Could more be done to support this? Whatever the reasons, this illustrates the complex interplay of individual and situational factors, including social comparison, that contribute to constructing emotional experiences in learning,.

Active, collaborative learning settings, like those created in these STEMM case studies, facilitate development through providing opportunities for students to test out their understanding, often in collaboration with peers. The disadvantage is that current 'shortfalls' in knowledge and skill is evident and comparable by oneself and others. As Student254 explained, the Physics seminar that required them to concept map their current understanding of the connections between concepts, made them feel:

"Completely and utterly petrified about exams 'cause I don't understand anything, and have confirmed that after doing the concept map...I enjoy seminars but I can tell everyone understands a lot more than me... I would say most people felt pretty chilled, my group has a lot of fun together, and not as anxious as me" (Student254, PH).

Despite feeling strong negative emotion towards the exams and overwhelming volume that this student's degree structure represents to them, again they enjoy the seminars. This highlights the value, when researching emotion in educational contexts, of capturing and recognising the temporal nature of emotion and considering contrasting and changing emotion in analysis. In practical, educational terms, it underscores the importance of facilitating interactions that create contrasts of positive emotional learning experiences, to counter the negative experiences.

For some student participants, this intimidating upward comparison seemed to cause negative emotion, not only in relation to knowledge-related goals, but also to interacting, socially-related goals, such as contribution. Description of this feeling was often constructed in terms of language that related to distance and sometimes weight. Some referred to feeling a "burden" to perceived "stronger students". Student50, quoted below, used language to describe how they felt about their Year 1 EEE design project that gave the sense that students need to be strong and quick to keep up with the pressures of the curriculum. Failure to do this, relative to their peers' perceived academic strength and stamina, can weaken an individual's ability to contribute and participate. They also referred to the influence of group size. Inability to contribute seems core to their construction of a difficult emotional experience:

“I wish I felt more useful to the group. 7 people is a lot per group and I think in our group, it would have sufficed to have 5 people. When others get ahead, it leaves less for me to do and hence I wish I was contributing more. The others have gone far ahead and I feel as if even if I tried hard to contribute I wouldn't be useful because of how much I have to catch up on” (Student50, EEE).

Despite not overtly labelling their emotional experience as negative, as Student50 self-evaluates their inability to achieve their goal of contributing to this group project, there is a sense that they feel guilty, an internally directed, social emotion, but possibly also annoyed that their contribution is not enabled, a more externally directed emotion. This could be due to group member behaviour or the groupwork design, related to size, as they suggest, and expectations set around involvement. Groupwork is often reported to lead to negative emotion such as anger at the unfairness over shared assessment grades and unequal contribution (Popov et al., 2022). Reported negative emotion in existing literature is often from the perspective of those who see themselves as contributors, with research participants unlikely to self-identify as non-contributors. This present study sheds light on the emotional experiences of those ‘non-contributors’ who do not believe they choose this position. Acknowledging this could enable a more nuanced and inclusive view of so-called ‘freeloading’ students’ behaviour and strategies to address it.

This framing of learning in terms of distance travelled was highlighted by William, when referring to a deliberately public evaluation event, intended to signal the value of students’ outputs have produced during Design Week. Here William describes upward and downward social comparison that extends beyond the year group being assessed and has corresponding positive and negative emotional impacts, although probably less binary than he expresses here:

“We do this down in the turbine foyer, which is very public... We get all the staff down, not just the supervising staff. And I think sometimes the ME1s [first years] pop down see what's expected of them the year after...they see, you know, where, how far the second years have come from that point onwards. And I think that puts the fear of God in the first years, but it makes the second years feel better as well” (William, ME).

As highlighted by Manstead and Fischer (2001), the effect of social appraisal on emotion can occur in anticipation of the situation and be based on perceptions of how others will feel and expect you to feel and behave. Unsurprisingly, this is not always accurate or useful information for understanding how you will feel. This cannot only be misleading, but cause

cognitive dissonance and its own uncertainty, as Student173's description of how they felt at this midway point in Design Week illustrates:

"Surprisingly, if not suspiciously, calm. Also slightly worried. Before design week, it was bigged up to be this scary, stressful and chaotic week.

Speaking to students in higher years especially made it sound like this, but so far I have found it relatively easy. Yes, there's a lot to do, and yes, it's all totally new, but it isn't as bad as expected, which leaves me wondering if I'm not doing it right" (Student173, ME).

7.2.2 Helpful social comparison

Students from across the case studies also reported favourable inspiring upward comparisons, often referring to them as motivating. Data also gave insight into the attributions that contributed to, or were influenced by, emotion. Student80 made a helpfully balanced attribution for peers' success based on their perceived effort (unstable) and intelligence (stable). There was still some sense of unpleasant social emotion such guilt or fear of not contributing, but this appeared to have an activating effect:

"My peers are hard working and intelligent which makes me want to be at the same level of understanding as them to ensure I don't let the team down - possibly seeing them as a form of motivation" (Student80, LS).

Whilst Student279, below, seemed to recognise the value of this active, collaborative learning approach and the self-evaluation opportunity it provided in helping them to identify areas for development. Their apparently incremental mindset led them to attribute future improvement in ability, and subsequently results, to putting in more effort.

"the seminar means easier way to find weakness in learning and solving problems. It is activating, as our peers are pushing me to do better in my study...They showed great progress in every week and this helps me to get motivated. I think I still need to work hard to get better results" (Student279, PH).

This evidence of the positive effects of social comparison is interesting, as much previous research has focussed on negative impact, for example on self-belief (Marsh et al., 2008) and self-evaluation amongst first year medical students (Jackman et al., 2011). Across the dataset, I noted that if students judged the situation as allowing them time and opportunity to improve, along with a more incremental mindset, this seemed to contribute to construction of more positive emotional experiences.

It is surely relevant, in terms of what makes this upward comparison inspiring, rather than intimidating, that the 'comparer' is able to identify tangible evidence of their sources' progress. I would argue that this is an example of a 'coping model', as opposed to a possibly more intimidating 'mastery model' (Schunk et al. 1987). Based on their study on the influence of peer models on 10-year-olds with maths learning difficulties, Schunk et al. (1987) found that learners observing a peer model with gradual acquisition of fraction skills (a coping model) gained increased self-efficacy, ability and performance outcomes when compared to observing a peer model with rapid acquisition of fraction skills (a mastery model). To my knowledge, coping models have not been considered in the context of HE, but student data suggested that they have great potential for contributing to constructions of positive emotion, in relation to challenging learning. Specifically, data suggested that engagement in collaborative learning can help to make coping models themselves, and approaches towards success more tangible. Student95 described how they move between playing the role of coping model and learning from coping model peers:

"They're very supportive in general and greatly contribute to both my productivity and engagement with stats. I try to contribute effectively to the team in areas I'm confident about, so I can be supported where I am less confident" (Student95, LS).

Examples across the dataset of this positive interpersonal emotional interaction between peers appeared to influence goal setting and achievement that not only related to individual performance goals, such as a revision, but also to more collaborative contribution: "They encouraged me to put more effort into the discussion" (Student265, PH).

For others, upward social comparison might be a tolerable side effect that goes along with the benefits of valuable peer learning and companionship. Where students recognised the value of social interaction, both for supporting achievement of their academic and more socially-based goals, this counterbalanced negative affect to some extent: "They teach me new things, it's nice to talk to them but also I realise that they are a lot more clever than me" (Student244, PH).

Darnon et al. (2010) argue that social comparison is not just relevant when pursuing performance approach goals, to demonstrate superiority, as previously thought, but is also applicable to university students who adopt multiple goals, including mastery goals (for example, getting more proficient) that serve performance goals. If students adopt a mastery orientation, rather than a performance-avoidance orientation to learning (for example, avoiding getting beaten), upward comparison will be less likely and unhelpful associated emotion avoided.

As Sanjay observed, active, collaborative learning can give rise to new emotional experiences, due to evidence, including other's emotion, that inform social appraisal and evaluation, and which, I argue, students come to understand through emotion socialisation:

"I think there's definitely a whole new set of emotions...Because with passive learning, I guess the negative emotion is generally like, 'I should learn, maybe others have learned, I haven't learned or something'. And then you're procrastinating maybe... But with active learning, there's a feedback where you see that every time you go to a face to face session, and you've not done the pre-reading or something. The feedback is instant. You see everyone, others have learned. So there's a lot more emotions, I think. (Sanjay, MD).

7.2.3 Normalising social comparison

Sometimes students' comparisons with their peers' abilities or emotional responses did not lead to evaluations of upward or downward social comparison, as Student83's quote illustrates:

"We are all trying and have different strength. Everyone is sharing their thoughts and explaining how they reached each answer. I was interested in the subject and putting effort in" (Student83, LS).

Student83 seemed to make what I am terming a 'normalising social comparison'. They recognised that through social comparison peers appreciate their differing strengths and their emphasis is on sharing understandings for the benefit of the group's development. Student83's attribution for successful engagement is interest and effort. This is an example of where social comparison, based on tangible evidence of peers' ability, combined with an incremental mindset, can be very beneficial. This student goes on to suggest that this learning opportunity enables them to align with what Janssen et al. (2023) define as identity goals and supportive principle goals: "makes me feel like I am capable of smthg I didn't expect. It makes me feel professional and challenged" (Student83, LS). Realised alignment between Student83's and their teacher's goal, and ability to self-evaluate on this basis, may be a reason why they are less reliant on upward social comparison.

"Many students reported feeling similar to peers and, even when this was not in relation to positive emotions, this sense of emotional connection seemed beneficial" (Ippolito and Kingsbury, 2024, p6). Student48's quote is illustrative of this wider sentiment:

"Everyone feels the same way, so I don't feel as isolated or concerned that I'm the only one feeling this way. So in that sense there is a group morale in that we all 'struggle together' but it's helpful to lean on others and talk to each other when we're stressed out" (Student48, EEE).

Other students referred to "being allies" and "in it together", suggesting emotional convergence contributed to group identification (Parkinson, 2019). This also indicated that social comparison that contributed to the normalising effect could be emotion-informed, and not just based on perceived academic progress (Ippolito and Kingsbury, 2024). This is an example of social appraisal, where another's perceived emotions influenced a students' own appraisal (Manstead and Fischer, 2001).

Not all students appreciated the value of emotion-related information, as Student28 reported: "Hearing about the struggles of other students is not encouraging" (Student28, EEE).

As discussed in the previous chapter, the interacting cognitive and emotional load felt by students when collaborating should not be underestimated.

7.2.4 Social comparison and competitiveness

Festinger (1954) described a motivation for social comparison as wanting to improve our performance, including vis-à-vis other people's actual and pre-empted performance, and that desire to maintain one's superior ability could lead to competitive behaviour. Garcia et al. (2013) identify how individual and situational factors contribute to social comparison and lead to competitive behaviour. These include individual orientation towards performance goals and away from mastery goals, and the relevancy of the dimension under focus (e.g. academic performance) to self, as this has significant implications for identity-based goals. Situational factors include a zero-sum game approach to assessment, based on a norm-referenced rather than criteria-referenced allocation of marks, where one student's gain is another's loss. Several teachers referred to students' competitive behaviour and the negative emotions it provoked for teachers, including because of the way it impeded their collaboration-related educational goals and associated culture change. This included Ina who identified individual and situational factors, including luck-related attributions of success and misconceptions of assessment grading, as contributors:

"the ones who are more confident, if not necessarily more able, talk a lot about their excellent exam results...One of the first things they do when they arrive and talk to each other is 'what exam results did you get?....It's really annoying, because if they, if they think like that, then they won't help each other...There's no 'this percentage of people get a first and if you're

unlucky, then you fall outside that percentage'. It's not like that at all" (Ina, CH).

Hemal agreed that competitive behaviours originate from the students but, in doing so, highlighted the paradox of staff and students blaming the other party for competitiveness:

"we get NSS feedback where they say, 'the department has created this culture of competitiveness', and What? When? Where? How? No, we haven't...there are hardly any examples, I can promise you. Hardly any examples of times when we have been the ones encouraging the competitive environment. However, they do get graded and they do receive feedback. We don't encourage them to compete" (Hemal, PH).

Hemal's reconsideration that there may be examples where the departmental culture and assessment contribute to competitiveness, illustrates the way that contradictions are embedded within social constructions of educational meaning regarding indicators of success. These, in turn, contribute to co-constructions of students' and teachers' associated emotions. But teachers only have so much influence over constructions about what counts. For example, their feedback on student work should reduce the need for social comparison and competitiveness, by offering an alternative source of evaluative information, but only if it is used by students to support mastery, rather than only performance, goals.

Hemal's further analysis factors in forces beyond the university that make powerful contributions to wider society's constructions of academic success and failure, and anxiety related to the need to compete in an uncertain and uncontrollable graduate job market:

"there is this like gold standard of the 1st and then the 2:1. Below a 2:1's viewed as failure by a lot of people. It's like a 2:2 is a good degree and should be viewed as a good degree, but it's simply not... Students, when they get to a position when they have to resign themselves to, you know, like, getting a 2:2 are very upset. They consider themselves a failure, even though it's literally not. ...that's partly due to a competitive job market" (Hemal, PH).

Interestingly, only one of the 280 student participants referred directly to competitive behaviour in terms of influencing their emotions negatively, commenting: "They [peers] cultivate a competitive environment however it is quite stressful in discussions when they brag about being ahead etc." (Student167, ME). When referring to how teachers contribute to this feeling of competitiveness-related stress Student167 responded "They [teachers] encourage a decent working environment and are helpful to some extent" (Student167, ME).

Hamza illustrated when a potentially competitive situation seemed to encourage curiosity and drive learning:

“they want to make a pendulum and make it more accurate...And when they see other groups they get some ideas, they say, ‘Oh, one group made it two metres. How can we make it even longer?’. And then it's like competition between them as well. So I feel whenever they have that freedom, or the need, they usually, I think they are happy to have that cross checked with other groups as well” (Hamza, PH).

He also concluded that contributing factors included freedom of time and freedom from summative assessment in this part of this module.

7.2.5 Teachers socially comparing

On the surface, teachers seemed more immune than students to social comparison. This could be because they are generally at a less transitional point than students or because there is less opportunity for social comparison. Although teachers are very visible to their students in classrooms, they are much less visible to their teacher peers. Where social comparison was described as contributing to teachers' emotional experiences, it had similar characteristics and goals to students. Batman indicated the tendency towards comparison at points of teaching transition, creating what he considered as unnecessary discomfort: “I think every time a module leader changes that there's this kind of undue pressure that, ah, you have to do something different and change things, so you can make your print on it” (Batman, ME).

Social comparison also related to saliency of the dimension and alignment to a goal. The example of social comparison below was especially salient because it related to a goal that Hemal and Hamza were trying to address and were apprehensive about, regarding titrating the cognitive load of group assessments:

“there's another module that the students have, where...they have very complicated assessment criteria, whereas Hamza and I made ours very simple. And it was interesting to hear the students' comparisons and how basically, like, it turned out the students were getting really stressed...in the other set of seminars, because they were, they were being presented with not only the problem, but a relatively complicated list of instructions as to how the assessment would be done...that got in the way of actually working on the maths and the physics. It was more or less an

experiment... They moved off that quite fast when it wasn't working"
(Hemal, Physics).

Hemal's final two sentences suggest that using social comparison for self-promotion and to fuel competitiveness is misaligned with his professional values and identity goals, as an individual who is loyal to their colleagues. In his appraisal of a teaching colleague's active teaching, William used evidence of context, including lack of similarity in job and available time, to inform his comparison. This is in contrast to some students' appraisals that lack evidence. His strategy may avoid this social comparison feeling intimidating, but neither does it seem to be felt as inspiring:

"he's structured his lectures almost, almost militarily, so there are never more than maybe 10 or 15 minutes of one particular activity. But it took him like an entire term to restructure his entire lecture course to do that. I mean to be fair, that was kind of his job at the time. He wasn't required to do anything else, which makes a huge difference" (William, ME).

I believe it is important that teachers who put thought and effort into their practice are aware that their goals are being achieved and appreciated by students. Ina appeared to use the data I collected from her students as additional evidence for her downward comparison and as an endorsement of her proactivity: "I think the comments are reflective of reality. I mean, if I'm in the lab I do go and I'm proactive and I help them. I know not all my peers are like that" (Ina, CH). There were very few examples of downward social comparison in this study, possibly because it is perceived as socially unacceptable. However, perhaps in order to establish higher teaching standards, like Ina, or to signal a legitimate concern over teacher work overload, like William, downward comparison can be a helpful approach.

7.3 Evaluating student achievement

HE contexts involve high levels of evaluation, not only between socialising agents socially comparing their relative success, but more official and high stakes evaluation, such as teacher assessment of students' academic performance and achievement, and students' evaluation of the quality and impact of teaching. Both have significant meaning within and beyond the university and this seemed to contribute to the construction of a category of emotions called achievement emotions (Pekrun and Perry, 2014) in students and teachers. As introduced in the theoretical framework, Pekrun's (2006) CVT of achievement emotions provides a useful lens for analysing how different students' and teachers' perceptions of control and value influence their emotions. Furthermore, considering how notions of control

and value are socially constructed in STEMM university classrooms helps us to appreciate both the intensity and variability of the emotions experienced.

7.3.1 Impact of assessment on learner and teacher emotion

Teacher participants overwhelmingly reported that assessment was a one of the biggest sources of negative emotion for students, most often characterised and labelled as stress and anxiety. This was reported as leading to predictable student behaviour that limited engagement and temporarily affected wellbeing:

“So normally at this time of year, the major submission they have coming up is ME2 Design report. And basically, it's like someone's set off a bomb in the department, everyone's depressed and anxious and frantic and nobody turns up for tutorials. If they do turn up for tutorials, they're on their computer, and it's got the design report on there. It just takes over the entire student consciousness” (William, ME).

This not only interrupts learning, but for the duration of such periods impedes the teaching goals of those whose classes are scheduled, as students prioritise key assessments. In accordance with CVT (Pekrun and Perry, 2014), the pressures that lead to anxiety can be exacerbated by perceived value, such as high weighting of an assessment, and lack of control, including over peer contribution. For example, Student45 described their experience as: “Highly taxing. Given that this project had a high weighting and my group was short-handed, there was a lot more burden on our shoulders” (Student45, EEE). In terms of interpersonal influence, William's quote, above, illustrates that the high value students place on assessment reduces teacher control over engagement.

Findings illustrated how emotions caused by assessment created tension between students and teachers, with some students' apparent single-minded focus on assessment and grades generally frustrating and sometimes angering teachers:

“if it's a piece of summative assessment, the students are completely fixated on the grade...And we were talking to students today and they are just so grade orientated. You know "why did I get this grade?" And you know, for us it's a defence. It's a defence mechanism, isn't it” (Andrea, LS).

The defensive action that Andrea referred to is teachers' response to the threat of needing to defend their professional assessment judgements. Andrea explained that this, in turn, can affect the way teachers give feedback to this cohort and be damaging to teacher-student

relationships. Andrea's colleague Clare, like Hemal earlier, pointed to differences in interpretations of meaning conveyed by assessment metrics:

"When someone...gets a 68 from me that's something to celebrate...And, you know, my feedback would reflect that...You did all this stuff really well, very positive, here's a couple of things to think about next time. Whereas they think, well it's not 100%...There's a very big mismatch between what we think of the grades and what students think of the grades. And I think until they marry up, giving feedback is going to be really difficult" (Clare, LS).

So even in an aspect of education with seemingly definite properties, such as an assessment grade, different meanings are socially constructed, impacting on learners' and teachers' goals, individual emotions and how those emotions interact and influence practice and relationships.

The sometimes seemingly obsessive focus that students give to summatively assessed work and resulting grades is to some extent understandable. Students find themselves in a context which, whilst claiming that it's all about learning and mastery goals, can look suspiciously like it's all about assessment and performance goals. Messages and cues include grading, ranking and lots of focus on assessment elements of the curriculum. In this context, feedback can feel like criticism and a threat to students' self-concept as an individual who identifies, and is/was identified, as a high achiever, rather than feedback having a developmental function. Tariq described the negative emotion felt by students who perceive feedback as criticism:

"I do get a lot of complaints about feedback. Some of those are, I feel are, are genuine complaints... And there is this thing that they do not like negative feedback. They don't see it as something to improve on. If it's too much negative feedback, they see it as criticism. So yeah, it has to be very well written if you really want to reap the benefit from it, especially when it is bad feedback" (Taariq, EEE).

Although he seems to recognise this as an unhelpful emotional response that can prevent students from making use of feedback, he indicates being similarly emotionally orientated and empathetic towards what he refers to as 'genuine complaints' directed at teacher colleagues' feedback. Furthermore, despite his conception of feedback as 'something to improve', I suggest that the language he uses here, and possibly with students, unknowingly reinforces and contributes to social constructions of this information as 'negative' and 'bad'

feedback, and something to be avoided. This provokes a negative emotional reaction in him, indicated by his interpretation of student feedback on feedback processes as 'complaints'.

Jones et al. (2020) highlight the tensions created when attempting to balance student and staff wellbeing against effective assessment policy and practice, and consider the psychological threat posed by feedback, but only from a student perspective. Whilst teachers in this study recognised the importance of assessment for motivating effort in a way that supports learning and progression, overall they thought it stifled more desirable emotions that promote inter and intra-personal development. They also stressed their perception, that some students will only focus attention and effort towards aspects of the curriculum that are assessed.

Although there has been much integration of innovative assessment practice and movement away from closed book exams at this university and sector-wide, we seem to be locked in an intractable cycle with no clear way of designing out the unhelpful behaviours and resulting emotional tension that evaluating learning create. These beliefs, behaviours and emotions run deep, evidenced by Hemal's reflections on what Pekrun (2006) describes as habitualized emotion, that may eventually occur out of habit rather than in response to a real 'threat': "It's weird that we've frightened them about exams, because none of the components are examinable in the seminar" (Hemal, PH).

7.3.2 Coping with assessment stress

It seems evident that some assessment-related performance goals cannot be avoided in a university context and that a feasible alternative could be to design curricula that lead students to both performance and mastery goals, and ideally performance via mastery goals (Darnon et al. 2010). This is easier said than done. A feature of collaborative learning, such as TBL, is that assessment is integrated into teaching sessions, thus creating the potential for performance and learning/mastery goals to be integrated. This can have negative emotional effects, as some students expressed, of spreading feelings of test anxiety across the term, instead of containing it to specific points. Interestingly, in many cases the sense of peer support mitigated against much of the strong negative feeling, especially when teachers designed for and paid attention to this. Student97 described the TBL session making them feel:

"Anxious because we are completing a test/ summative piece of work but also excited because i really like my team and we work very well together

so i learn a lot from them but also when we work together i feel a lot more productive and dont feel as 'dumb' as the solo sessions we do for the irats [individual tests]" (Student97, LS).

Despite the prevalence of upward comparison, Student97 reported feeling less 'dumb' when completing assessment with peers than individually, illustrating the great variation in students' psychological responses to their environments. What Student97 labels as feeling 'anxious' before may again indicate habitualized emotion (Pekrun, 2006) that students construct based on previous assessment experiences. However, it is possible that the feeling of being excited and productive could also become a habitualized emotion, recognised and reinforced for this student through reflection, such as that prompted by this present study's emotion-related survey questions.

Student97, having responded initially that the teacher does not contribute to their feeling, then reflected, when prompted to consider how the teacher might be feeling: "I would say relaxed. He doesnt seem too stressed and isnt pressuring us or scaring us with the material or the test, he is almost always in a happy mood and is willing to teach us" (Student97, LS). This provides evidence of emotional influence between teachers and students, that I suggest contributes to emotion socialisation, in terms of learning how to cope in perceptibly high achievement contexts.

As discussed, stress, defined as a response to a situation with personal relevance, is an inevitable part of life and of learning, especially when we have clear and ambitious goals. Some of this stress can be helpful for motivating action and effort (Cottrell, 2019), as most students recognised. But additionally, across student data, stress seemed to signal the value of attendance, participation and collaboration, as this was strongly experienced as a way to share and relieve stress, as Student98 explains:

"Depends, when we are teamworking in person or listening to mini-lectures in person and I understand what's going on I feel happy and confident, during the pre-reading and the iRATs [individual tests] I don't understand anything and feel stressed and confused and I hate statistics and don't want to have anything to do with it" (Student98, LS).

As Student98 explains, the emotions and resulting motivation to learn associated with individual study and assessment is in sharp contrast to the social learning context. I suggest that this contrast is important for motivating engagement and to resolve it would be unhelpful. In this way stress-approach and stress-relief (as opposed to stress-avoidance) by students enables the teacher to achieve their teaching goals of student participation and attendance.

Some students were aware of this and described having emotion-related goals that they were evaluating achievement of, intertwined with cognitive goals: “I try not to panic and I celebrate myself when I figure out a concept / solve a problem” (Student98, LS).

7.3.3 It's worth it: assessment and positive emotions

The examples of assessment that seemed to promote most positive emotion such as enjoyment, satisfaction and pride amongst both students and teachers, involved an element of risk for both parties. Risk was often attributed to high value of the task that made it worthwhile in terms of effort, and to perceived loss of control and potential for incompetence, as illustrated in this example:

“They build these robots and they're putting them out... So I mean, that naturally is going to create some stress because the students are very exposed at that point...All their peers are going to see how well they're going to get on. On the other hand, mostly what I see in that demo is that students are proud of what they've done. They see it as being the culmination of their work. You know, their work has been worth something” (Brian, EEE).

Brian reflected that students who consider themselves to have more practical competence, possibly undervalued until now, appraise this increase in student-led control as a positive feature and feel like:

“finally they're being unleashed, they've been constrained by being told exactly what to do all year, and now they've got a bit of freedom. And they, especially if they've done a bit of electronic project work before, you know, they're very keen to show off and get started” (Brian, EEE).

Brian's colleague, Victoria, highlighted the need to create time and space to focus, and to reduce cognitive load given over to juggling tasks, if students are to cope with, and take advantage of, the freedom to creatively consolidate their learning:

“they said that they really enjoyed the fact that they could finally you know, tackle a problem to have more freedom to sort of put together everything they had learned in the year and work only on this rather than having to balance 10 different things” (Victoria, EEE).

Data suggested that such assessments enabled students to achieve multiple goals, including their mastery goals, and led to construction of positive emotion: “Makes me want to

learn as it's interesting and a cool project so actively want to research and learn and stretch myself to design the best product" (Student33, EEE).

Some reports of positive emotion were attributed to a recognition that academic achievement was contributing to the attainment of identity goals. Student54's illustrative quote reflects the dynamic nature of emotional experience in learning, in part because some evidence of goal achievement and value can only be recognised retrospectively:

"I feel happy and excited that I am progressing as an engineer...the fact that I can complete tasks to directly contribute to a project like this is evidence that I have been learning somewhat effectively throughout the year and that my time in university has been worthwhile even if it didn't feel that way at times during the year. This has made me excited to learn more and remedied the daunting experience of learning for the exam period" (Student54, EEE).

Student54's quote illustrates how experience contributes to construction of anticipated emotion and, in turn, to building self-efficacy beliefs around future academic challenges. Furthermore, their quote indicates how performance goals can contribute to mastery goals, as advocated by Darnon et al. (2010), and vice versa. This may be because, like Victoria, Student54 considered this a fair and motivating point in the year to be assessed; their appraisal of control was that they felt sufficiently competent to undertake the assessment. Student 162's response, as someone midway through an intensive Design Week, demonstrates the contradictory nature of achievement emotions, how longer-term perspectives and goals could help students to cope with current emotional discomfort and this fine line between perceiving stress as a response to mastery challenge or to a threat (Folkman, 2013): "I felt so stressed I struggled getting out of bed this morning. But also excited about doing this in the future" (Student162, ME).

Data also suggested that assessment type can influence the nature of emotional connection between students and their teachers. There is an element of uncertainty and risk for teachers in these more authentic, creative assessments, as introduced in the previous chapter. They often have a higher value in terms of weighting for students, and increased effort and reduced control for teachers, leading teachers to also experience uncomfortable emotion. As Brian explained, the hope is that this will be counterbalanced by the higher learning worth: "I'd say that's, that's definitely another trade off in the project, which is the stress of telling them to go off and do this competition versus the, the worth that it gives the work they are doing" (Brian, EEE).

7.3.4 Broadening achievement goals and rewards

Although considered by some to be a self-centred, complacent and potentially demotivating emotion, the words 'proud' or 'pride' within the data gave a useful clue as to where value could be found, beyond assessment grades. This is where the distinction between hubristic pride (arrogant and based on internal accountability for success) and authentic pride (altruistic and based on success due to a specific behaviour) is useful (Oades-Sese et al., 2014). Where pedagogic goals were successfully articulated and shared, either between peers or students and teachers, this seemed to create the possibility for educational and emotional convergence, that gave both parties a sense of control and value, despite factors beyond their control. For example, Alex expressed pride as he evaluated the strength of his module design:

"it's really important that not every university teaches programming. Something that's going to give you a bit of a USP [unique selling point] when you leave this place and you should be proud that, yes, you've got to Imperial. Yes, you've also got...a curriculum that's going to help you stand out from the rest of them" (Alex, LS).

Where students recognised positive emotional exchange as an outcome, this helped to broaden perspectives beyond the dominant belief of value as high assessment grades. Student179 spontaneously referred to the value of peers and a shared goal:

"I feel challenged in a productive way...I feel like my interaction with the rest of the group and the fact that we are working together effectively towards a shared goal is the main factor of this positive experience....we all make a significant contribution to the project. I always make sure to express my opinion and volunteer to help everyone my group with their tasks as much as I can" (Student179, ME).

Such student data can give teachers the confidence they need to push beyond assessment design that they know encourages performance goals, to design assessment for learning, with more social learning goals, such as collaboration and peer support. Mastery goals have also been shown to correlate positively with the inclination to help others, to cooperate, and to share knowledge, especially when individuals with mastery goals experience that their performance can still be further improved (Poortvliet, 2016). Where teachers had successfully achieved meaningful assessment, they felt it important to share a sense of pride, as William explains:

“Within an hour, we've got those posters printed, and we put them on boards, and we have an exhibition. And the students find it's really nice that their results...are on a big screen, and they talk about it to other people” (William, ME).

Student115's quote illustrates the sense of pride that seems all the more important when it can be attributed to effort leading to success:

“I feel motivated and quite proud of myself for cracking [R programming] when I have very poor fundamental knowledge about it. This feeling has an activating effect on my learning because I wish to keep having this type of feeling in the future” (Student115, LS).

It also resonates with Atkinson's (1958) observation that reward for success can come in the form of an anticipated emotion. I wondered whether this student would have recognised and articulated this affective dimension if they had not been presented with my emotion-related questionnaire?

7.4 Teachers being evaluated

Having focussed on both student and teacher emotion related to evaluation or assessment of students/learning, in this section, I will consider emotion related to evaluation of teachers/teaching. I will examine the bidirectional relationship between teachers' emotional experiences and evaluation of their teaching; both the ways that evaluations impact on teachers' emotions and how emotion informs evaluation. I will also discuss the potential for students' emotion as a useful form of evaluation data. In terms of contextual framing, my experience leads me to believe that currently there is an overemphasis on student voice in the evaluation of university teaching. Although student evaluation of teaching offers valid perspectives and is essential for understanding a diversity of student experiences, this is only one form of evaluation, complete with biases, prejudices and misconceptions. The shift towards student voice in relation to teaching quality has occurred over the last 15 years, as the introduction and increase of student-paid fees paved the way to what some refer to as a consumerist approach to HE (MacFarlane, 2020). This includes satisfaction surveys, such as the National Student Survey (NSS), providing a metric by which to compare and rank universities that, I believe, conflates learner satisfaction with teacher/teaching quality. This is a concern that is shared by others and has been linked to problematic emotional experiences and loss of wellbeing amongst university teachers (Lakeman et al., 2022).

Being evaluated by students led to a range of achievement emotions amongst teachers in this study, including frustration, anger and anxiety, but also enjoyment and pride. Where teaching staff sought their own evaluation data for aspects that they wished to understand, epistemic emotions such as curiosity, surprise and confusion were described and observed. Types of evaluation data referred to in the study included the university's official student evaluation (formerly SOLE¹, now MEQ²), informal, interim evaluations, assessment outcomes, conversations with students and observations of student behaviour, including attendance and participation.

Teachers are not immune to prevailing discourses which influence their own evaluations of their teaching practice. To me, Erica's quote indicates that it is not just students that need to be orientated to, and reminded of, the purpose of university and what teachers should be judged on the basis of:

"They're consumers nowadays, Kate, so they expect, 'we have paid you money, we expect you to dump the answers in our lap and preferably ones that get us A stars' and understanding 'No, you're here to do the learning. We're here to help you, assist you, teach you, sometimes shepherd you, whatever. But we are not here to do the learning.' We've kind of got past that" (Erica, MD).

A sense of agency around interpreting and responding to student evaluation feedback, such as the one Erica described developing, can be difficult to achieve, especially in light of conflicting pressures. Literature in this area indicates that different teachers respond in different ways, often dependent on their amount of experience and the nature of the feedback, with teachers receiving what is perceived as negative feedback, experiencing more negative feelings (Flodén, 2016). My analysis indicates that it is not always so straightforward.

In order to capture this agentic spirit, consideration of teacher data presented in this section was informed by Frenzel et al.'s (2020) inspiring 'Reciprocal model on causes and effects of teacher emotions'. This model, as outlined in my Theoretical Framework, highlights how teachers' emotions are influenced by teaching goals and teachers' appraisals of goal success. Accordingly, teachers' appraisals and resulting emotions are based on four appraisal dimensions which I express as questions, developed from Frenzel et al. (2020):

¹ Student Online Evaluation

² Module Evaluation Questionnaire

- Goal attainment: Based on available evidence from student behaviour, did I achieve my goal?
- Coping potential: Do I feel capable of achieving and optimising my goals?
- Accountability: Who is responsible for whether the goal was achieved or not?
- Goal importance: How important is achieving this goal (or avoiding impediment) to me?

To my knowledge, this model has not been applied to a university context but seems very appropriate. One main difference between HE and previous educational levels is the role and significance of student evaluation of teaching data. This adds a valuable dimension, in that data received directly from learner evaluation can inform teachers' evaluations of goal success, albeit based on teacher's interpretation of student data, which may be influenced by emotion.

As discussed in the Theoretical Framework, achievement goals play a significant role in emotions associated with teaching, as well as learning, although this is less well considered. Here, alongside Frenzel et al.'s (2020) framework, 'Goal achievement theory' (Butler, 2012) and 'CVT of achievement emotion' (Pekrun, 2006), as well as 'Emotion as social information' (van Kleef, 2009) will be applied to analyse how teachers construct meaning and emotion, based on student evaluation data, and how this influences student-teacher emotional interactions.

7.4.1 Emotions as indicators of teaching goal attainment

Teachers' accounts gave insight into the variety of emotion-related evidence they used to evaluate achievement of their teaching goals, beyond formal student feedback. This ranged from an emotion teachers experienced, such satisfaction from an anticipated outcome, to their observation of desirable student behaviours which they recognised as having a positive effect on themselves emotionally, as George described:

"the quality of the year depends a lot if there are talkative students or not... And it was amazing. Because you go in, and you feel people, you know, hear people speaking. Right. Otherwise it's just silence and that's depressing" (George, EEE).

As observed amongst students, George's quote indicates how subjective and individual emotional experience can be, and therefore, how subjective this makes evaluation. George likes teaching talkative students and this informs his positive evaluation and emotion. Just like students, teachers also experience contrasting emotion depending on the teaching

activities that they value more, or feel more competent at and in control of, as Sanjay explained:

“not the actual front facilitation, the behind the scenes thing, that's the bit I enjoy the most, the bit with the designing the assets...Possibly, because it's more under, I can take... So I have this issue where...I'm thinking of something and then I just lose my thought. And it's completely fine to be that way when I'm doing the assets, because it's just me and the asset” (Sanjay, MD).

Sanjay's visual learning assets are exceptional, such that Student195 recognised both their cognitive and emotional impact: “I really like Sanjay's slides. They're really useful for learning and I'd say the best slides I've seen so far. I can tell a lot of hard work and effort has gone into them so I appreciate the work ethic he has” (Student195, MD). Looking at teaching and learning through an emotional lens offers possibilities for more inclusive experiences, where individual teachers, like Sanjay, can play to their strengths and what makes them feel positive, at least some of the time. This is likely to lead to quality experiences for students, that facilitate meaningful connections.

I suggest that teaching evaluation is especially powerful when the achievement is closely linked to what the teacher values educationally, and the resulting student and teacher emotions are aligned. Ina described persevering with several approaches to finally achieve an important goal:

“I introduced asking students to read a paper, a Chemistry paper...We did it in a workshop...We tried to do one in a whole lecture theatre, that was a bit of a disaster. And we did one in small group tutorials. And the students who got the exercise and enjoyed it, there was the one who wrote really, really nice comments in SOLE about how much he loved doing this, 'it's fantastic, this is what I wanted to do at University'. That is incredibly satisfying...It was an experiment in teaching and you actually got the result. Whereas a lot of the time you experiment in teaching, you don't actually get much of a result” (Ina, CH).

I suggest this is a teaching mastery goal. Thanks to Ina's curiosity about how to integrate literature appraisal into her UG chemistry teaching she found a way that meant those who valued the learning (and possibly Ina's effort) benefitted cognitively and emotionally. The feedback via SOLE, that Ina referred to, is significant because it does not focus students' attention on one session. This student will have recalled this experience in particular,

suggesting that it was very salient to them, thus making Ina's evidence of impact more valuable. Ina's response indicates that she makes a goal consistency appraisal (based on evidence from student behaviour, did I achieve my goal?) and a goal conduciveness appraisal (do I perceive that student behaviour contributed to achievement of the goal?) (Frenzel et al., 2020).

Participating teachers also reported experiencing positive emotion linked to teaching goal achievement when they perceived students to have gone above and beyond an anticipated learning goal, as Simon described:

"I think there's some really special moments sometimes when a student brings you, for example,...some crystals in the lab, and they said, 'Look at this, look at what I've made'. And there's a real sense of pride...It's not just, 'I've ticked the box and I've achieved' but also there's the kind of ownership of that success and, and a real positive feeling about it" (Simon, CH).

It seems that Simon was referring to the student's achievement and pride, but this may also have been vicariously felt by him, as the teacher, and contributed to future motivation. As highlighted by Frenzel et al. (2021), the emotion teachers participating in this study often described experiencing, as a result of observing learning, is a reward in itself. This reward is not purely experienced psychologically, but also physiologically. Based on neuroscientific evidence, a connection can be made between the neurochemical reward for anticipated achievement, that is secreted dopamine, for the satisfaction of actual/perceived achievement, secreted serotonin, and motivation to sustain effort towards goal achievement in educational settings (Lucas-Oliva et al., 2022).

For teachers, positive emotion such as enjoyment and feelings of success may not come from the topic they are teaching, but rather from the expectation that their impact, and the value for students, will extend beyond that learning experience, as Alex explained:

"I don't enjoy statistics and programming as content specific things. The thing that I particularly enjoy is that once a student gets it...when they sort of get programming and they get statistics at its fundamental level...This is such a transferable skill it for me, I feel successful when I know that they can take that forward into another module" (Alex, LS).

According to Kirkpatrick and Kayser Kirkpatrick's (2016) model, the impact of teaching can be evaluated at four levels: Reaction (e.g. at the level of engagement observed by Ina), Learning (e.g. as acquisition of skills and confidence noted by Simon), Behaviour (e.g. as

transfer of application to another context, as anticipated by Alex) and finally Results. Evaluating at the level of Results is very difficult to achieve but seems evidenced by the kind of emotional influence described by Antonia as her ultimate indicator of successful impact over the longer term:

“foundation year doctors, who we invited to teach with us, and it just thrills me when they will say at the end of the session, ‘I just love this’. Now that’s pretty powerful... And the joy to me...to have people coming back to us as junior doctors who’ve been through our teaching, historically, and who say ‘I want to teach because I know this is what makes the difference’
(Antonia, MD).

Antonia’s quote highlights both reciprocal exchange of emotion between medical colleagues of different generations, and the role of a mutually valued focus for learning, in influencing emotion and associated motivation.

In response to me asking whether students appreciate teachers’ effort, George referred to feedback direct from students, noting the difference between newer and more senior UGs: “for my module in the fourth year, definitely...the students love the way I teach them and they tell me” (George, EEE). Later he commented: “Because these are fourth year students so they don’t complain about things anymore. But yeah, I suppose they appreciate it anyway” (George, EEE). I wondered whether, rather than this being because they had given up complaining, due to lack of effect, this might be because at this stage in their degree, through emotion socialisation, they are able to recognise what good teaching and learning feels like and are able to pick up from emotion-related signals that teachers like George care about their learning and experience.

Teachers regularly reported feeling more positive emotion when teaching smaller groups, in flat classrooms. Data suggested that this may be two-fold: they feel this environment is better aligned to their educational goals and it is more conducive to transmission of emotion-informed feedback. Andrea’s quote indicates her interpretation of the bidirectional, reciprocal nature of emotional interaction that provides evidence of students’ expressed enjoyment in response to her expressed passion, that may not be possible in other teaching settings:

“So the seminar room...you get much more of a vibe, and you can tell how much more they’re enjoying it because you can do a lot more with a, even a group of 50, you can still do a lot more than in a big lecture theatre. And

it's just the layout of the room...I think if you can get your passion across, they really do, they really respond to that and it comes back in the feedback" (Andrea, LS).

Andrea's appraisal that the room is conducive to her achieving her teaching goals, and resulting positive emotion, may also influence the inferences she makes about students' positive emotion.

7.4.2 Influence of emotion on changing teaching goals

In the same way as some students perceive assessment to be a threat, so some teachers see the potential for threat to their self-concept as competent professionals in evaluation of teaching. With my participants, this was evident in the context of the official student evaluation of teaching, SOLE and MEQ, and the UK sector-wide NSS. As Hemal vividly explained:

"I don't think anyone who has never been through the process of receiving SOLE feedback...can appreciate just how nerve-racking it is when you, when you sit at your desk, and then in your email comes, your SOLE feedback is attached as a PDF, your heart goes in your mouth, and you click on it...if you've got like, 50 good comments, and then one poor one, the one you remember is the poor one. It's just like, oh, just so horrible" (Hemal, PH).

This strength of negative emotion could be attributed to number of factors. As Hemal and others recognised, like their students, teachers can become fixated on the few negative results. This may be partly due to the high salience of evaluation data such as internal SOLE or MEQ, used in promotion decisions, and external NSS, used to rank universities, and how these contribute to social constructions of what is valued educationally, including by senior leaders. This, combined with the lack of control, due to the sense of externality of things being done to you, and lack of context relevancy, specificity or timeliness, which prevented teachers from doing anything to respond directly, contributed to sense of powerlessness and sometimes threat response. The tensions it creates amongst otherwise agentic teachers were well captured by George:

"I don't know exactly how it works at a higher level...Why, for instance, [Directors of UG Studies] may feel the pressure of acting on some single comment and so on, right. But yeah, I always found the NSS very, very problematic. More than the SOLE, because the SOLE at least is specific,

right, to a module. I know that if there is a comment, I know exactly what the comment is about, right” (George, EEE).

Amongst teacher participants generally, I did not detect a sense of anxiety in relation to teaching experiences and wonder whether, unlike the schoolteachers described by Frenzel (2014), that although these teachers confront uncertainty, they did not appraise their potential to cope as being low. My teacher participants, a motivated and self-selecting group, demonstrated sufficient self-efficacy to try alternatives, draw on the support of colleagues and to relate to students. As engaged teachers they demonstrated feeling aware of what was going on for their students, as George indicated above. Conversely, maybe this general sense of control and competence is why negative feedback from a surprising and very public source, as described by George, was seen as such a threat:

“a couple of year, years before that there’d been an issue...of students going to Facebook, complaining about [a colleague] in a very unpleasant way, right. So I was a bit er (pause) er scared by this, right. And I started to think, ok, how do I try to make a selection process that improves quality but at the same time doesn’t makes me responsible, you know (laughing) for, for the selection itself?” (George, EEE).

This could be considered an example of an ability-avoidance goal (Butler, 2007). However, because George described multiple goals (Janssen, Westbroek and Borko, 2023); to improve the quality of learning outcomes, maintain his self-concept and reputation as a highly competent teacher and avoid being scared, as well as strong coping potential (Frenzel et al., 2021) thanks to previous evidence of well-received innovative teaching, he actually achieved an ability-approach goal (Butler, 2007).

Unlike Kogan et al. (2010), who found that female teachers were more likely to experience negative emotion, of the 23 teachers involved in this study, it was the males that expressed strongest negative emotion. Numbers are too low to offer generalisations, or to speculate on gender effect, but this seemed striking enough to warrant mention and future exploration, especially in STEMM contexts. It may have been because the female teacher participants had built up greater resilience, owing to their past emotional experiences and/or were better at regulating their emotion, including separating evaluation outcomes from self-concept. It may have been that they did not want to talk about it.

Despite its negative reputation, the official, internal evaluation, SOLE, was also drawn on as a persuasive source of evidence, especially when it included reports of students enjoying an approach, in this case TBL, in a way that felt rewarding to the teacher: “I pushed it a lot, you

know. I said to a lot of people that it works well, you know, SOLE is very good (George, EEE).

Some teachers mentioned how they responded to student feedback, sometimes collectively, in a way that both served to regulate emotion and also to analyse feedback via an emotionally informed process. As Ina explained:

“Sometimes there's a lot of swearing and shouting and laughing. In most part, you kind of look through their comments, and comments are often more interesting or useful than the numbers. Then you look for the ones that are ridiculous and you kind of discount them, maybe have a laugh or you shout a little bit about them. Then look for the ones that are constructive, be that positive or negative. And maybe think about doing something about those ones” (Ina, CH).

Despite having a sense of proportion that being an experienced and reflective teacher often brings, Ina demonstrated taking student feedback seriously. Interestingly, her decision to act on feedback seemed to be influenced by convergence between hers and students' emotion and orientation (Parkinson, 2019), in this case, shared annoyance about colleagues' failure to meet marking deadlines:

“for the full three years this lab course has run, various problems have meant the marking has not happened on the timescale it should... So those comments are entirely accurate. And we'll try and do something about those. But no, I don't necessarily change things just because the students comment” (Ina, CH).

Conversely Hemal and his department's student representatives' emotions converged to construct a shared emotion resembling anger. Although both teacher and students seemed to have the same goal – to improve the quality of teaching – they seemed to have very different orientations about what the approach and outcome should be (Parkinson, 2019).

“I know that they've [student representatives] said things like, ‘Right, in order to make a change, let's all put negative feedback for blah course...and really hit it... And if the official feedback comes out bad, that gives us leverage to make changes’, which is extraordinarily counterproductive” (Hemal, PH).

Because both were angry, but were blaming each other for different things, these convergent emotions did not reflect convergent orientations, instead they produced conflict (Parkinson,

2019). As Ina, Hemal and other teachers asserted, they do not change their teaching just to please students or to avoid their own unpleasant emotional reactions to feedback, as was observed by Arthur (2009). Even though my teacher participants did not all have a lot of professional experience, like the experienced teachers in Flodén's (2016) study and unlike the inexperienced teachers, they did not describe making unjustified changes to teaching. Rather they, often seemingly unconsciously, factored the complex and contradictory nature of emotion into their rationale for teaching choices. This takes courage, as it was often seen to be against the prevailing discourse, which is perceived to favour students' emotionally-based preferences as Simon observed: "You hear people saying, 'Oh, the students won't like that. Oh, can you imagine the students will be kicking off if we do this', and that seems to be what steers a lot of what happens" (Simon, CH).

Even when teachers reported making changes on the basis of student feedback (often socially constructed by teachers as representing 'complaints') these were well thought through:

"the first year, my peer assessment was five marks out of 100. And in the SOLE, I received the feedback to increase it, right. So then I made it 10 marks the year after. Um it's a valve. It's also a defensive mechanism for staff...Because whenever there are complaints in [about] the group power. We say 'Okay, but there is the, the peer assessment. If there are issues, please write it there and, you know, and these will be taken into account. Right. So in a way, it's, it's a way for students to think, 'okay, okay, I'm working more or this person is not working.' There is accountability and at the same time, it's, er, for me to try to get away from the drama of the groups" (George, EEE).

Peer assessment is an interesting example. In this STEMM institution, it is increasingly used in assessed teamworking situations to give students a sense of control. It is perceived as creating fairness in light of perceived threat from peers who do not 'pull their weight' and negatively impact group grades or cohort rankings. This is framed as a logical decision, based on weighted numerical calculations. From my emotion-informed perspective, I interpret peer assessment used in this way as influencing reciprocal emotional interaction through shifting the perception of where value and control sits. As George recognised, this takes the emotional heat out of the situation for teachers as they distance themselves somewhat from evaluation of student contribution. However, because the mechanism given to students is generally based on a performance goal orientation, sense of mistrust and the assumption that students can accurately and fairly judge and reward contribution, it often

serves to reinforce this more individualistic orientation and can undermine the collaborative attitudes and behaviours that team working is meant to foster. It rewards some students (possibly those with performance goal orientations) with the ability to direct their annoyance and blame at peers and leaves others feeling uncomfortable, guilty or threatened. I am aware from conversations with students and teachers and unpublished data that many students do not like it, as they find it divisive, and can negatively impact on peer relationships and risk-taking, as this student quote highlights:

“They [peers] don't actively do anything to trouble me but knowing that the peer assessment exists does stress me out to some degree and makes me want to not leave them with a bad impression” (Student159, ME).

A particularly interesting grouping of data was around teachers' beliefs about enjoyment in learning and how this influenced their practice. Kris' quote captured general sentiment from teacher participants who expressed wanting students to enjoy their learning, not least of all because this contributes to teachers' own construction of enjoyment, but that this cannot be at the expense of other educational goals:

“I love it when our students enjoy themselves, but to say that we only have to do things that they enjoy is something that I see as a negative thing. But our students sometimes seem to think that it always has to be about their enjoyment” (Kris, ME).

It is interesting to think about where this teacher perception comes from. Many students reported experiencing pleasurable emotions as a result of the teaching session / project, including enjoyment and even excitement, but I did not get the sense it was expected. In many cases, emotion was expressed as mixed, for example, “exciting and stressful”. In these cases, and even when students stated unpleasant emotion having been provoked by the session, the vast majority reported recognising the activating effect of this emotion on their learning. It could be that teachers were internalising messages from a wider HE discourse about the need for students to be satisfied and happy, or even from western society more widely, that the goal is to feel or at least express happiness. This has been described as toxic positivity, including by those advocating for a counterbalance to societal pressure to desire only positive emotion (Cain, 2022).

Clare questioned feedback from students that specifically asked for teaching methods that promote enjoyment: “multiple times in feedback in the last year students... have asked for lectures to be more fun... ‘like some jokes or some memes into your lectures, because it's more enjoyable” (Clare, LS). Clare's quote reflects a different construction of enjoyment by

students to that expressed by teachers, who often associated learner (and teacher) enjoyment with successful interactions or relevant topics. It is well documented, particularly in the positive psychology field, including Frederickson's (2001) 'Broaden-and-build theory of positive emotions', that positive emotions like enjoyment can have a valuable impact on learning, such as by broadening attention, promoting creative thinking and collaboration, and enhancing memory. However, it is also understood, based on psychological and neuroscientific evidence, that so-called negative emotions, such as anxiety, can lead to valuable cognitive functioning such as focussed attention, accuracy and critical thinking (Muis et al., 2021).

Ina helpfully linked the presence of enjoyment and the absence of feeling stressed and reflected that she did not consider this appropriate or helpful: "We focus too much on creating things that students will enjoy and things that students will not be stressed by" (Ina, CH).

Hubert's intercultural (and cross-generational) educational perspective is useful for critically reflecting on goals and expectations in relation to students' emotional experiences, where they come from and how the expectations themselves influence emotional norms:

"That was in [country name]. And I can certainly assure you that nobody cared about enjoyment, or at least from my point of view...You could still enjoy it, if you, you know, did the experiments with a positive attitude, but I don't think it was the kind of something that they actually took into consideration a lot" (Hubert, CH).

Clare's critical consideration of potentially 'negative' student evaluation feedback offers an interesting example of divergent conflicting emotion, that in this case demonstrates teacher agency. It also provides another illustration of socially constructed meaning in educational settings, with some students perceiving challenge as the threat, and teacher perceiving challenge as the goal.

"the kind of negative feedback with journal clubs was 'they were very challenging'. Students use the word challenging a lot. Almost as though they thought that was a negative thing. To me that's like great. If that's, if that was challenging that's exactly what I wanted" (Clare, LS).

An example of complementary divergent emotions might involve Clare feeling pity for students based on their perceived anxiety and making the journal club less challenging. This is where educational contexts may differ to other social contexts and where redesigning

learning approaches to design out uncomfortable emotion would not be helpful. To illustrate this complexity, Frenzel et al. (2021) refer to valence incongruent links between teacher emotions and learning outcomes, based on attribution theory. They explain that if a teacher expresses annoyance or frustration at a student's failure, the student will interpret this as the teacher believing they have the ability and should try harder (favourable competence beliefs), whereas teacher sympathy conveys the belief that the teacher does not believe the student can succeed (unfavourable competence beliefs). Interestingly, this is contrary to the outcome of other theories of emotion transmission that will be explored in the next chapter.

The final point, when considering how emotion influences teaching goals and their evaluation, relates to experiential learning, experimentation on the part of the teachers and how this makes them feel about change. As Kris explained, having time and continuity gives teachers space to take risks as they know they can regain control: "the nice thing about, about Design Week is we've got five days so we can also try something on one day and if it doesn't work, then you don't do it again" (Kris, ME). The Covid19 pandemic gave rise to forced, emergency experimentation and this resulted in more dramatic changes and testing out of educational ideas that teachers may have otherwise feared the consequences of. As George explained, he finally found a way to achieve his goal of increasing content complexity: "I changed because of Covid. But then I found out that actually worked quite well. Because now I can make a tRAT (team test) which is much more meaningful" (George, EEE).

7.4.3 Emotions as valuable educational information

So far in this chapter, I have considered emotions as phenomena that reciprocally influence how students and teachers feel about their assessment and evaluation experiences and their appraisals of success and failure. Now I will consider emotion explicitly as useful information in this context, with discussion informed by van Kleef's (2009) 'Emotions as Social Information' (EASI) and other aspects of social appraisal theory.

Based on my study, I argue that the emotion data found in high quantities in teaching and learning contexts, including teaching evaluations, should be treated as valuable but highly subjective, dynamic emotion data, and not objective, factual information, as it is often handled. For example, it is striking that students in the same EEE module cohort make such different evaluations of the way that teachers influence their emotion during their project, as these responses illustrate:

1. "There are no teachers in the group project" (Student49, EEE).

2. "Not much teaching has happened in this project for me personally. Being given just the instructions is more comfortable for me" (Student46, EEE).
3. "Don't really know if we've bothered them too much by asking so many questions" (Student31, EEE)
4. "[Staff help] by explaining the project brief and assessment criteria well and providing great responses to questions on teams and edstem" (Student54, EEE).
5. "A lot. Teachers were encouraging and also easy to approach whenever we faced difficulties" (Student42, EEE).

At one end of this indicative spectrum of responses is Student49 who suggested that the perceived absence of teachers means they have not contributed to their emotion. I do not know if they are relieved or annoyed about this. From Student46's response, I infer that they feel more comfortable due to the scaffolded independence. Student31 shows concern for how students may make teachers feel, suggesting they have (been given) the impression that not bothering teacher with questions is a desirable thing. A module lead might use this emotion data to reflect on why such meaning is constructed. Conversely Students54 and Student42 evaluate teacher support as being readily available and helpful. Experienced teachers who implicitly recognise this diversity in emotional response, appeared calm when considering even mixed, emotionally-informed evaluation data:

"I had like a quick read off of it [student feedback] and there are students for which the project has been great because they've been able to satisfy their curiosity. They've learned, you know, all of this. For some others it's been, you know, confusion, anxiety, frustration with their peers and themselves. So I think we've got the whole range" (Victoria, EEE).

Reading the additional emotion data generated by this study seemed valuable to some teachers for evaluating the success of their approaches. As Hemal's response suggests, it gave new insight that current data (or its interpretation) had not previously revealed.

"this is great for me to read and can be really useful in future seminar planning...[I]n our own little informal bits of feedback we've got on the seminars, we've never sort of asked questions quite like that and that's super useful...That's really nice obviously as a teacher for me to see because it means they know that I care about them" (Hemal, PH).

It can also give tangible evidence of success at a relational level, that is hard to capture and is a counterpoint to a prevalent discourse of HE as increasingly consumer-oriented and transactional. Others commented that there were few surprises in my study's student data.

In the context of our interactions, I interpret this as suggesting that they already consciously ‘collect’ and use emotion data through the process of teaching, rather than that they don’t think this data is valuable. Or perhaps, for some reason, they were unable or unwilling to show me that they were surprised by the data, a reminder that what research participants say and what they feel/think may not always be the same. Additional emotion-data led some teachers to be reassured that, on balance, they were handling potentially alarming dimensions, like student stress, well. Especially when learning to manage uncertainty and associated stress was a teaching goal, this was valuable but elusive emotion evidence, as Kris fed back:

“a couple of people were talking about stress and things like that but I think we do that in a somewhat contained level. So I read all those things. And was like ‘oh these students seem happy.’ So my take on it, even though I didn’t do the counting, was this is what we are trying to achieve” (Kris, ME).

Consciously thinking about observed emotion as a source of evaluation data also led teachers to consider an absence of perceived emotion as evidence of success, although obviously this needs to be triangulated with other data, due to issues with misinterpreting emotional signals. This was especially important when it supported a teacher’s instinct, but was contradictory to a dominant discourse, for example, that students only value teaching directly aligned to assessment, as Hemal illustrated: “in the seminars, I’ve never seen, there’s no evidence to me that students dislike it when we do things that aren’t purely to help them get through the exam” (Hemal, PH).

Teaching trio James, Vivek and Sanjay talked about emails from students that conveyed anger about the unfairness of an assessment question that they initially referred to as unusual and critical. Later James returned to this, apparently wondering whether students’ expression of emotional discomfort was a signal that they were on their way to learning to become more comfortable with uncertainty:

“one of the other things that we wanted to weave in here was getting students comfortable with uncertainty...If you get them to that position and yeah, you know, students emailing in angrily, maybe they haven’t quite got to that point just yet where they’re comfortable with uncertainty. Maybe somehow, maybe that’s a question we should ask” (James, MD).

This conception of student anger as useful information could be productive especially, as James suggested, if it leads to more explicit probing. The quote also demonstrates James' curiosity around emotional meaning-making.

Clare highlighted the value that emotion-data could have for students when evaluating their learning which would possibly, in turn, influence their evaluation of the teaching:

"I think sometimes they forget the bits that they enjoyed. Almost if you, if you push them and say, 'well, give me three things that you really liked about the course', they do that. But...that's generally not what we ask them for" (Clare, LS).

Directing attention to positive emotion could counterbalance the natural tendency of most humans to unconsciously focus on more negative aspects of life, including learning, and offer a less biased evaluation of learning and teaching successes. This is aligned to the positive psychology field that emphasises the value of deliberately focussing on positive emotion for personal wellbeing (van der Kaap-Deeder et al., 2023), to which this present study could contribute. Furthermore, in the follow-up interview, Alex reflected on how by being supported to generate and reflect on emotion-related data, students might regulate their emotion in learning and put their natural comparing, evaluative tendencies to more positive use:

"I think it's important actually, from asking the [research survey] questions, that we can see that there are at least instances, whether that's comparing themselves to their peers, comparing themselves to me or...comparing this course to other parts of the course, that probably can spin things in a positive way. That, you know, 'okay, I might not be enjoying programming and statistics right now, but I know that there's other parts of my course I really enjoy'...It's just the lens from being 'everything is negative' to there is some positiveness there" (Alex, LS).

This seems even more important because, as Alex also observed in the emotion data generated by this study's student survey, some students appeared to rely on external and objective evidence of success, such as how many questions they got right, rather than their own emotions:

"The only thing that was surprising they that, they link a lot of their emotions to how well they *think* they're doing. They don't necessarily always see progress. But they think...'how am I doing on a mark scale?'

It's not like, 'Oh, I left this session and felt a lot better about it.' It was 'I could do the questions kind of thing. And I could see that my group could do the questions'" (Alex, LS).

As an outsider, this did not seem surprising to me, but perhaps Alex observes many emotions in the classroom that students could pay attention to in order to conclude that they are successfully progressing, alongside more objective evidence. Clare, Alex and Andrea discussed how teachers might be more critically and collaboratively reflective in the way they used the emotion component of student evaluation data, with Alex suggesting that this could be more meaningful "if people were more open about the types of comments that they receive, and make students think a little bit more" (Alex, LS).

In the same way as students respond differently to feedback on assessments, teachers have differentiated responses to evaluation of teaching. As Lutovac et al. (2016) also concluded, this was influenced not by the nature of the feedback but by the interpretation of the feedback, as well as teachers' mindset, including their goal and what they valued, and whether their coping strategy was problem-focused or coping-focused (Folkman, 2013).

7.5 Chapter conclusion

This chapter has explored the impact of approaches for evaluating in STEMM learning and teaching contexts, including social comparison, assessment of students and evaluation of teachers, on individual emotional experiences. It has also considered how evaluation of, and by, socialising agents in both directions influences interpersonal emotional interaction and illustrates the ways in which these interactions are powerful and varied. I propose, based on findings presented in this chapter, that students and teachers use very similar emotional signals to evaluate achievement of their goals. Their various interpretations, as well as *being* socially constructed, based on prevalent discourses and cues, contribute to social construction of their own and each other's emotions. By examining the existence and value of emotion data in evaluation processes, this chapter presents an argument for both increasing the quality of the data gathered and improving the way it is interpreted.

Furthermore, through interrogating core educational experiences of learner assessment and teacher evaluation through the lens of socially constructed emotion, I offer possibilities for how learner and teacher relationships can be nurtured in the pursuit of learner, teacher and programme development goals, rather than these being in conflict. I advocate explicitly for reframing the processes of being assessed or evaluated as experiences that can involve

construction of positive emotion, rather than emotions associated with the threatening, divisive and disempowering interaction students and teacher often perceive it to be. As I have illustrated, evaluation depends on emotion-informed orientations regarding what is valued. These can differ between and within people, change over time and impact goal setting, evaluation of successful achievement and associated emotion. Therefore, it is important to understand the role of emotions in this process. It is not about finding solutions, but about better understanding how people feel, why and how orientations and associated emotions can be more helpfully influenced.

8. Empathising: Reciprocal emotion regulation for complex goal achievement

8.1 Chapter introduction

Empathising is defined as the capability to perceive, understand and respond to the emotional experiences of others (Szanto and Krueger, 2019, Zaki, 2020). This process characterises the third and final core theme in this thesis' findings. In this chapter, I present data that illustrates how empathising functions as a means of supporting and connecting socialising agents, students and teachers, as they pursue their goals in challenging learning and teaching environments. I deliberately frame what I have discovered using the construct of empathy, rather than compassion, even though the term compassion is increasingly used in the HE sector (Andrew et al., 2023). Gilbert et al. (2018) define compassion in university curricula as "the noticing of distress or disadvantaging of self or others and a commitment to reduce or prevent it" (p5). Likewise, associated literature and university policy appears to position the individual or group at which compassion is directed as in distress or disadvantaged. I am concerned this, to some extent, justifies criticism that so-called therapeutic approaches position all students as vulnerable (Ecclestone and Hayes, 2019). For example, are we at risk of socially constructing assessment as something that students (and teachers) expect to feel harmed by if we explicitly wrap a need to be compassionate around it? By using emotion as a lens for enquiry, I have come to understand that emotional experiences and interactions are very dynamic, contradictory and nuanced, but also implicit, embedded and authentic. We should be cautious to avoid inadvertently disrupting existing delicate balances. Brené Brown (2021) conceives of compassion as the daily practice and empathy as the skill set that supports this. I am interested in how university students and teachers develop and deploy this skill set. Empathy is sometimes characterised as stopping short of taking action to help another person, however, researchers in the field of empathy generally consider pro-social behaviour, acting on the emotion we perceive and understand in others, to be key component of empathy (Zaki and Ochsner, 2016).

Even the term empathy is often used to frame a situation where someone is struggling. In an academic context, this can result in framing as a deficit model the very normal need to develop capability to handle increasingly complex cognition and associated emotion. Szanto and Krueger (2019) highlight the situated nature of empathy, that includes the complex environments in which experiences and feelings develop. This helps to broaden the possibilities of empathy to include reciprocal support offered between socialising agents in

university classrooms as they interact, dynamically co-constructing emotion and ways of coping, succeeding and adapting cognitively and emotionally. In this chapter, I will illustrate the characteristics and processes of empathy being enacted and experienced in STEMM classrooms and analyse the complex and contradictory ways in which these influence learning, teaching, relationships, goals and emotional wellbeing.

In the previous two chapters, I have considered how the individual and shared goals and experiences involved in 'Knowing' and 'Evaluating' in HE STEMM contexts strongly influence reciprocal emotional interaction between STEMM university learners and teachers. This chapter will begin by explicitly exploring how cognisant socialising agents are of the ways they influence each other's emotional experiences, and the processes involved in this. To deepen my analysis and interpretation, I draw on the work of psychologists, Jamil Zaki and James Gross, both of whom have recently integrated empathy and interpersonal ER to consider in more nuanced ways the goals that empathisers aim to achieve. I apply this specifically to challenging STEMM academic contexts to understand how this contributes to social construction of emotion.

8.2 Students regulating their own emotions

When examining ER it is useful to begin by thinking about the beliefs, goals and strategies individuals have for regulating their own emotions. As the professional, it is reasonable to assume that it is a teacher's role is to regulate both their own and learners' emotions in relation to the goal of teaching effectively (Sutton, 2004). As the expected role of students is primarily to regulate their own emotion, I will begin by considering findings that give insight into their competency and awareness relating to emotional self-regulation, or intrapersonal ER. I suggest that this is an important pre-cursor to empathising. As set out in this thesis' theoretical framework, a central premise of ER is having a goal to influence emotion, although it is not universally believed that this is possible (Gross, 2015).

In particular, students' responses to the survey question "How do you contribute to this feeling?" gave a sense of their lay conceptualisation of ER, and an awareness of ER goals. Their responses can be categorised into three broad groups. The first group referred to their attempts to regulate their own emotion (intrapersonal regulation), the second group interpreted this question as how they contributed to their peers' emotion (interpersonal regulation) and a much smaller, third group, did not respond, with several responding, "I don't know". From the first category, some students demonstrated strong beliefs that emotions can be self-regulated, as Student30's more extreme example illustrates:

“I believe emotions are controllable and determined by the attitude and vision. So begin with the change of attitude, be humble, and be willing to learn things rather than worry or complain about the current situation” (Student30, EEE).

Table 8.1 maps examples from students’ responses against Gross’ (2015) ‘Process model of emotion regulation’ to illustrate the nature and range of intrapersonal ER strategies reported.

Regulation Strategy (Gross, 2015)	Evidence of hedonic ER	Difficulty in regulating / Upward regulation of negative emotion
Situation selection Selecting a situation based on anticipating specific emotional experiences.	Preparing themselves in advance: “[I feel] interested but also tired...I’ve improved my sleep schedule to a healthy level so I’m feeling less fatigued than i did before” (Student223, MD). Prioritising emotionally positive situation: “I feel really motivated because it’s creating things. I literally have no interest in playing games (which I enjoyed a lot), but thinking about the project. Its wonderful to have something working created by myself” (Student39, EEE).	“Perhaps I could’ve done more at the beginning to have avoided this situation” (Student50, EEE).
Situation modification Intentionally modifying a situation to alter its emotional impact.	“Before i enter the session i usually feel anxious however after i settle in the class and start working with my peers , i slowly get rid of the negative/anxious feeling and i feel more uplifted” (Student97, LS). Problem-focused coping (Folkman, 2013): “By always questioning myself on how to do better and willing to learn / find innovative solutions to problems” (Student19, EEE).	“Going in to it nervous can sometimes make it worse but that is hard not to do” (Student8, CH).
Attention deployment Externally or internally focusing	Focus on positive: “I can find certain topics that I personally care about this helps me focus” (Student205, MD).	“make it worse by thinking [of] other situations that I have felt this way” (Student32, LS).

attention with the intent of altering emotional responses.	“even if I haven’t had the greatest morning I still try [to] start the class with a positive attitude and forget about anything that is upsetting me” (Student94, LS).	“I think I add to [stress]. Bring it up actively in conversations” (Student172, ME).
Cognitive change Altering the emotional impact of a situation by changing one's appraisal of the situation.	Balancing appraisal of academic pressure with value to social and future goals: “I think it is a balance between aiming for a good grade and just having fun with the project. Therefore, I feel under a lot of pressure, but am able to cope due to the fact that I know this is a simulation of real life” (Student175, ME). Cognitive change through process of reflection: “Anxious, nervous, extremely frustrated, under pressure, worried... Yes, after doing such a[n] intense project... I think I would choose some non-engineering disciplines after I graduated... think I am doing great with my job. I sketched lots of graphs and did many calculations to check whether our design is feasible” (Student185, ME).	Difficulty in reframing mistakes as learning: “My somewhat idiotic behaviour is the reason why I keep doing the occasional thing wrong so I contribute mainly to the stress” (Student6, CH). “If I cared less and just accepted it [learning online] I would probably have an easier time going through this” (Student122, LS).
Response modulation Altering felt or expressed aspects of the emotional response.	Recognising how physiological, experiential and behavioural aspects interact: “I think my mindset coming into these sessions often has an effect, I was very tired in this one and so when challenged got frustrated quite easily, whereas normally I would have enjoyed the challenge” (Student151, LS).	Difficulty in modulating response: “My stress has led me to be irritable and have arguments with the group, creating a vicious cycle.” (student43, EEE).

Table 8.1: Mapping of student participants’ intrapersonal emotion regulation strategies against Gross’ (2015) ‘Process model of emotion regulation’

Overall, and as Table 8.1 illustrates, it was evident from student data that, in support of their academic goals, students deploy a range of ER strategies. These include hedonic goals to up-regulate their positive emotion and down-regulate negative emotion (e.g. enjoying

engaging in learning tasks, reducing nervousness) and instrumental goals (e.g. staying focussed in order to contribute). I found the range of ER strategies surprising and impressive, given that, as cohorts, students had been given no explicit input on ER. Across the datasets, second year students reported a greater range of self-regulation strategies than first year students, suggesting they may develop them through experience and emotion socialisation. Barriers to ER identifiable in students' responses sometimes related to under-developed and conflicting goals. As part of ER, some students recognised an explicit relationship between cognition and emotion, and this seemed to contribute to achievement of hedonic and instrumental goals, as Student66 illustrates: "I tried to keep an open mind and feel enthusiastic about the content which also would have contributed to understanding the content better" (Student66, LS).

8.3 Students regulating each other's emotions

Although to scaffold this chapter, I began by briefly considering learners' insights into intrapersonal ER, it was evident from student data that they did not consider themselves as regulating emotions in a vacuum, but through interacting with other people in that context. Table 8.2 (below) maps examples of students' descriptions of interpersonal ER against Gross' (2015) 'Process model of emotion regulation' which was originally developed to explain intrapersonal ER and has more recently been used to analyse interpersonal ER (Taxer and Gross, 2018). It has been criticised for its limitations when analysing dyadic interpersonal ER (Xiao, 2022) but, having experimented with several frameworks (Niven et al., 2011, Maccann et al., 2023), I have found Gross' model to be helpful for considering the multi-directional emotional influences in university classrooms.

Regulation Strategy Gross (2015)	Evidence of interpersonal ER
Situation selection Selecting a situation based on anticipating specific emotional experiences.	Students select sociable behaviour: "Tutor group are friendly, engaged and dedicated which creates a good team spirit" (Student34, EEE). Choosing to attend: "Teammates who were present built up a sense of camaraderie and it increases my eagerness to learn, and vice versa" (Student47, EEE).
Situation modification	Turning to collaboration: "they helped because we discussed a lot when facing problems, and it feels less stressing when we actually solved them together" (Student31, EEE).

Intentionally modifying a situation to alter its emotional impact.	Reorganise: “Try to notice when the team slows down to bring up them together to reorganise” (Student176, ME).
Attention deployment Externally or internally focusing attention with the intent of altering emotional responses.	Shared attention contributes to feeling of social flow (Walker, 2010): “Since everyone is working it creates an atmosphere of focus. Usually everyone is on their own schedule” (Student172, ME).
Cognitive change Altering the emotional impact of a situation by changing one's appraisal of the situation.	Normalising emotion and learning difference: “I can also reassure other students that I don't feel confident in statistics or coding, and that everyone is learning at their own pace” (Student71, LS). Being positive: “I hope I'm positive and supporting about R [programming], and about the classes - I don't like it when people moan about things because it brings the group down” (Student81, LS).
Response modulation Altering felt or expressed aspects of the emotional response.	Not modulating response: “people sometimes are more likely to show off their worse sides when they feel more comfortable and this can impact rest of the group” (Student18, EEE).

Table 8.2: Mapping of student participants' interpersonal emotion regulation strategies against Gross' (2015) 'Process model of emotion regulation'

As Table 8.2, and the data more generally, demonstrated, students deployed a range of interpersonal ER strategies that indicated some recognised the relationship between emotion and cognition, and the need to respond to each other's emotion in support of mutual learning. Student responses indicated levels of differing awareness regarding how peers influence each other emotionally. For example, Student53, quoted below, recognised how up-regulation of negative emotion (frustration) by peers can be balanced by up-regulation of positive emotion (feeling relaxed) by the same peers. This realisation may contribute to their ER going forwards:

“When I disagree with them, it is highly frustrating as I feel like I can't effectively communicate my thoughts with them. But they also helped me a

lot and alleviate most of the workload. So peer support helped me feel more relaxed” (Student53, ME).

Students also explicitly indicated awareness of the emotional influence of peers in relation to achievement of their goals, including hedonic goals (feeling less anxious) and instrumental goals (sharing the load) or as inhibiting goal achievement: “Teammates help sharing the load and making me less anxious, but other groups/ competitors also increase the anxiety” (Student52, EEE).

“Some group members did not show up nor contribute to the project, while others took up the challenge and supported me throughout the process” (Student45, EEE).

Peers not showing up could be considered as an intrapersonal ER strategy of situation selection, in order to avoid anticipated undesirable emotion. Acknowledging this could enable a more nuanced and inclusive view of so-called ‘freeloading’ students’ behaviour and strategies to address it.

Niven (2017) describes interpersonal ER as having four defining characteristics: 1.) it is regulatory, about maintaining a state in alignment with a goal; 2.) it has an affective target and is aimed at changing their emotion; 3.) it is deliberate and effortful on the part of the regulator; 4.) it has a social target and this has implications for relationships between regulators and targets. Each characteristic has a neuroscientific basis, in terms of which areas of the brain are being recruited for ER processes (Niven, 2017). However, based on my data, in the context of university learning and teaching, with its multidirectional emotional influence, I would suggest that student targets may feel emotionally regulated by others, even though it may not be deliberate or even apparent on the regulator’s part. Furthermore, my data indicates complexity in ER, in relation to real-life educational processes, that may not be captured by current models. For example, Student187’s quote illustrates how ER contributes actively to the construction of emotion through interaction of intra- and interpersonal ER. They suggest that it takes time and inevitably involves other people in both directions, as sources and targets:

“Because I have last done Design more than a year ago, the archaic memories of my former expertise only began surfacing gradually as design week progressed. In the meantime, i felt inferior, overwhelmed by the sheer number of little details and calculations that has to be done, and instead having to rely upon my friends and teammates for support...However, once I started focusing upon what I can do, and slowly

explored what I used to know, I felt more confident in my abilities to contribute to the group” (Student187, ME).

Although Student187 recognised their teammates’ influence, it is possible that teammates were not aware of their role as sources of interpersonal ER, contributing to Student187 feeling inferior, and later, helping them feel more confident. If they were, would this feel effortful in a burdensome or developmental way and what would be the implications for the relationship? The quote also illustrates the different time frames over which ER strategies play out, from seconds to days, and how this can relate to recall and meaning making of past experiences. Student187 demonstrated applying cognitive change strategies, reframing their ability to contribute. This reappraisal process can involve a number of objects around which individuals reorientate (Parkinson, 2019), which, in Student187’s case, include knowledge, peer support and their contribution. It is likely that reflection, prompted by this study’s questionnaire, contributed to cognitive change. Taken with other students’ accounts of their emotional experiences, it highlights the value of group-based STEMM learning for developing students’ competence in regulating emotion and their interlinking academic, social and emotional self-efficacy. Later, I will consider the value of making this process more explicit and deliberate, within the context of STEMM learning.

8.4 Understanding how each other feel

In everyday usage, empathy is used as a noun to describe what we show (and are expected and encouraged to show) another person who we think would benefit from our attention and/or help. In neuroscientific and psychological terms, the construct of ‘empathy’ has great explanatory powers for enabling us to understand the process of how we become aware of how others are feeling and why, as well as how we decide how to respond, including through interpersonal ER. Using my data, I argue that empathy is both a process and tool at the heart of how socialising agents in university classrooms recognise how each other feel.

In the Theoretical Framework chapter, I explained that psychological literature broadly agrees that empathy comprises three elements:

- 1) automatic, rapidly occurring *experience sharing* of internal states via emotional contagion (affective empathy)
- 2) conscious, effortful *mentalising* that involves reasoning about how others may feel or be thinking (cognitive empathy)
- 3) *prosocial motivation* to help others (Zaki and Ochsner, 2016).

Next, I consider participants' instinctive awareness of the first of these two processes and how they influence participants' emotional interaction.

8.4.1 Experience sharing in the classroom

When referring to awareness of others' emotion and the impact this had on socialising agents, several students and teachers referred directly to the contagiousness of emotion and some referred to emotion's ability to transmit across the group: "My peers affect me positively since they always have a positive attitude and are also motivated to do well which is kind of contagious" (Student97, LS).

The few studies considering emotional interaction between teachers and their students have highlighted the contagious effect of positive teacher emotion such as enthusiasm (Frenzel et al., 2019) and happiness (Moskowitz and Dewaele, 2021). Students in this present study demonstrated strong recognition of the effect of positive teacher emotion, particularly enthusiasm, on their motivation to learn and even their peers' experience "He [teacher] was enthusiastic which made me more willing to engage in the activity...[Peers feel] Enthusiastic because of the enthusiasm of the teacher" (Student266, PH). Remarkably, some students also recognised the transfer of positive student emotion to teachers and potential impact on behaviour: "I feel like our class was engaged which would help them [teacher] be more enthusiastic about their teaching" (Student200, MD).

Teachers recognised the same bidirectional nature of emotional transmission and its positive relational effect, as Ina acknowledged: "They're telling you about something, they've decided they're going to give their presentation on this topic. You can talk to them about it. They get excited. You get excited. It's nice" (Ina, CH).

Student118 recognised the transfer and amplification of both positive and negative emotion: "I guess especially when I am learning in peers, the emotion gets amplified (anxious/happiness)" (Student118, LS).

Student113 suggested that this transmissible kind of emotional influence is more likely to occur between peers: "[Peers make] Greater contribution to this feeling, since there is greater interaction with them, and since we are supposed to be 'on the same level'" (Student113, LS).

Rather than just physical closeness, this may be explained by the salience of peer emotion, especially for young adults, who tend to be particularly sensitive to peers' emotions (Zaki and Ochsner, 2016). Teachers and students also commented that the emergency online teaching conditions created by the Covid19 pandemic created barriers to emotional

perception and understanding. Vivek described how this seemed to affect students' perception of teacher emotion:

“of course, the students will be able to pick up on your emotions. But I also think the buffer of the screen...if you think somebody's asked an excellent question, it's harder to get that enthusiasm across. If somebody's asked a question and you know, it's, you're not quite sure what they're getting at, then the confusion in your kind of manner also doesn't come across...It makes it slightly harder for the students to know how you're feeling because you're not responding to them face to face” (Vivek, MD).

Many participants expressed how they ‘felt’ others’ emotion in the process of learning and teaching. However, on second consideration, illustrative quotes in this section do not simply refer to unconscious, automatic processes, characteristic of experience sharing, but rather include an element of mentalising or conscious processing about the relevance of the emotional exchange and implications for individuals involved. For example, when referring to the contagiousness of positive affect, Student97 consciously appraised the similarity of their own and peers’ motivation ‘to do well’. This is not surprising, as research participants were asked to make conscious this process in order to articulate it, but it does align with current thinking that primitive emotional contagion (Hatfield et al., 1993) is limited as a way to understand how humans influence each other emotionally. My data also illustrates how humans build up a fuller, more useful picture of how others feel and why, via interacting affective and cognitive processes (van Kleef and Cote, 2022) as will be discussed.

8.4.2 Perspective taking and inferring in the classroom

The data provided strong evidence that the cognitive processing component of empathy, *perspective taking*, based on our ability to consciously mentalise about how others may be feeling or thinking is important in these STEMM university classrooms. This may be particularly relevant because “in order to accurately represent and respond to another's emotions the observer must make inferences about the knowledge, goals and appraisals of the other in a given situation” (Thompson et al., 2019, p279). As demonstrated in previous chapters, in this comparison-rich environment where ‘knowledge, goals and appraisals of the other’ are highly salient, there is plenty of evidence on which to base inferences about emotion.

Research participants identified various channels via which they consciously became aware of others’ emotions, including observations, conversations and emails. Some teachers

referred to “reading the room” and “getting a vibe”. Often these sources of evidence were used in combination, as Simon explains:

“kind of monitoring body language in the room and just this general sense you felt from the students, which I know you can't measure but it was just kind of a feeling you got through the interactions with the students. And when you ask, ‘oh, how's it going?’ and they go ‘yeah, yeah, we know what we're doing, kind of thing’. Those kind of conversations, we thought, ‘okay, right, they're feeling a lot more comfortable’ (Simon, CH).

There was variability between teachers. Some queried whether students would directly tell teachers about negative emotion, especially in relation to their teaching. Others commented that this communication did happen directly, especially, as Hemal explained, if the emotion was not directed at that specific teacher: “sometimes I'll talk to personal tutees and...they'll admit, they get angry about things outside of the sessions and there can be lots and lots of reasons for that” (Hemal, PH). As members of the same teaching team, Victoria referred to regular conversations with students about how they felt, whereas Brian reflected: “I've actually never talked to them about how they feel. And I don't think they have directly told me how they feel about it” (Brian, EEE). It may be that different teachers rely on different emotion communication channels and evidence, possibly based on their own perceptual preferences. For example, Brian was clearly very interested in his students' experiences and described how he could infer their emotion including from more embodied assessments, even online: “that came across in the video, because they put so much into how they could show off and you can see their excitement explaining it” (Brian, EEE). He logically expected that students might do the same: “I never tell them what I feel about this module directly. You know it's all going to be through, through body language and things like that, which I'm sure the students pick up on” (Brian, EEE).

More quantitative communication of emotions recognised by teachers included decreases in quantity of Mentimeter (e-voting tool) responses, assumed to indicate boredom, and peer assessment scores getting narrower, interpreted by teachers as more harmonious emotions relating to group working. Hamza reported another source of incidental data:

“It's always difficult to judge how other people feel because if they don't talk about their feelings it's difficult. But the feedback we get, for example, at the end of most seminars, I usually have a round of applause from the students” (Hamza, PH).

This illustrates how emotion-related information can aid motivation and relationship building in classrooms. It can also aid contextual understanding. In line with the social-functional conception of emotion, van Kleef et al. (2017) observe how people use deliberate cognitive processes to draw inferences about other group members' emotional expressions, to better understand complex social situations. The applause likely became more salient to Hamza because the teaching context was new, and relatively socially complicated and risky. His inferences based on students' emotional responses, that applause signalled appreciation, reassured him that things were going well.

Alex referred to making his processes for inferring about how students were feeling explicit to students:

“Look, if you're really struggling, then ask questions. But if you don't ask questions, then I'm going to look for fear, like fearful eyes'. I'm going to look for those, like, sort of behavioural cues that will help me to identify who is potentially struggling in a group or not” (Alex, LS).

Some session types seemed more conducive to teachers gathering emotion information that they judged to be useful, as Andrea and Clare explained:

Andrea: “a problem class is probably where I've found at the most. I think sometimes they don't tell you, but you can really see it and feel it...certainly it works for the positive emotions, like you can tell when students are excited by material without them saying, 'I'm excited about this.'”

Clare: “They're chatty. I think they're more bubbly.”

Andrea: “They're just smiley. Yeah, like bubbly. You can get that vibe.”

Ironman saw emotional inference as part of his role and was clear on how he achieved this: “But that's our job, isn't it, to read a student's face and know how they feel?” (Ironman, ME). This more essentialist understanding of emotion (Lindquist et al., 2013) and possibly paternalistic approach to managing it (Zaki, 2020) seems aligned with a conception of emotion as universal and linked to human expression. Yet it is likely that, in reality, Ironman combines reading of facial expressions with other emotion information available to him in this context. The importance of this triangulation is highlighted by Jessica when referring to the mismatch between inference based on perceptions of ‘negative’ facial expressions in the classroom and ‘positive’ emailed feedback afterwards:

“I’m always a little surprised, like I get those kinds of emails as well because, I tend, you see a sea of faces who perhaps look slightly bored and you think ‘why am I doing this?’ and so it’s a nice surprise” (Jessica, MD).

This could be explained by the teacher’s in-session misperception, including due to her attention being drawn to threat cues of less engaged facial expressions, or by a change in orientation of students once they have reflected on the value of her session, or a combination of the two. Either way, it highlights how subjective and potentially misleading, emotion-related data can be in single sources, at single timepoints. Kris underlines the value of collecting emotion information from different perspectives and time points and interpreting them accordingly:

“I talk to third year students, fourth year students and I ask them regularly: ‘OK, this is what we’re planning with Design Week. Do you have any ideas? Or do you have any advice?’ And typically, the typical feedback...I get is, ‘Wow, it was tough. But actually, it was really great’...I would say if you ask them once they’re in the middle of it, they don’t think it’s so great” (Kris, ME).

Data gathered through teacher interviews conveyed how valuable understanding the specific academic context is for perceiving and understanding how learners feel, and proactively using this as a teacher. This contextual, disciplinary awareness could be considered a component of teachers’ emotional intelligence, as Alex highlights: “I’m quite emotionally intelligent so I can get a good feel about how people are feeling just by speaking to them. And I kind of, because I know the disciplines I’m teaching, I can kind of pre-empt some of the things that they might be feeling” (Alex, LS).

Despite being identified as a key domain in university teaching (Mortiboys, 2011), emotional intelligence, as a concept, has been criticised for the role it may play in reinforcing the separation of cognition and emotion in STEM education (Lönngren et al., 2023). Alex’s quote, and others illustrate, how teachers deploy emotional intelligence within the context of STEMM teaching in an integrated way. As discussed in Chapter 5, teachers also referred to their own experiences as students in the discipline to support their inferences which, given too high a value, may lead to out-dated and inaccurate inferences.

In terms of evidence of emotion inference within student data, when asked how they thought the session / project was making their peers feel, the majority of students responded that

they thought peers would feel the same as them, often with similar attributions. This may have been a result of projection, especially if they judged peers to be similar to them (Ames, 2004). As suggested by Thompson et al. (2019), students also used inferences about peers' knowledge, goals and appraisals to understand each other's emotions. Insightful Student78, demonstrated awareness of how peers' differing appraisals for success, failure or relevance of goal achievement could account for differing emotional experiences across the cohort:

“my group is probably happy as well, we've been doing good on [team application exercise] since the beginning as well - the other students in the classroom are probably all a mix of different emotions, with the frustrated ones or sad/angry if the outcome did not please them and happy/joyful/proud if it went well. Some people could also be unphased by it if they do not care about the statistics part of the module (Student78, LS).

A risk with inference is that teachers and students may be influenced by prototypical scripts for Anglo-American versions of emotion, such as fear and excitement (Parkinson, 2019) and miss or misread expressions and emotional information of socialising agents' from different cultural backgrounds (Mesquita, 2022).

In this section I have considered emotional awareness in terms of how teachers and students perceived and understood each other's emotion. In the next section, I explore what the data revealed about how their emotions interact.

8.4.3 Converging, diverging and collective emotions

As introduced in the Theoretical Framework chapter, taking a relational orientation perspective (Parkinson, 2019) allows better understanding of differences in emotion between socialising agents and how they are constructed between people. Differences and changes in object around which emotion is constructed and orientation to that object, as indicated by the data, are interesting to consider because they enable analysis of emotional interactions and connections between participants, as well as facilitators and barriers. In terms of *converging* emotions, Hubert recognised the similarities between his own emotions as a teacher in the lab and students' inferred emotion, but that these emotions may be in relation to different objects:

“I would probably say that those [my emotions] are the same ones that we have chosen for the students, just in a different context. I definitely *hoped* that everything would go well. You know, sometimes I was *surprised* at

what students would come with. I was sometimes very *frustrated* with some students. Definitely...I would say all of them apply in a way, but maybe about different things" (Hubert, CH).

This is logical as teachers and students may have different goals and orientations. Simon referred to the convergence of surprise between students and teachers during the kitchen-based lab skills course. This shared surprise seemed to function as a signal and source of evidence of authentic creativity, a much-sought outcome in contemporary HE:

"for the experiments that we did in the chemical kitchen...they [students] kind of innovated a little bit and they were really surprised at the results. And I will say we were surprised at the results as well. Because there were some things that we haven't really considered could be done or why would anybody do it?...there was a lot of kind of creativity involved" (Simon, CH).

Convergence, in terms of emotion being directed at the same object by people with a similar orientation (Parkinson, 2019), was also seen to have mixed positive and negative effects on those involved, especially when the emotion was intensely experienced, as Student169 explains: "Seeing everyone so involved makes everything seems legitimate, even if it sometimes accentuates the stress" (Student169, ME). Many students used the term stress to describe their experience, especially in time pressured contexts.

The strongest reported example of negative emotion occurred when a student and Alex both experienced anger. The context involved teaching life sciences students on a challenging statistics module, during the Covid pandemic. The student was angry with Alex because they felt he did not care enough and was hindering the cohort in achieving their academic goals by deliberately making learning "as hard as possible". The student's emailed communication implied a convergence of student emotion within the cohort. Alex was angry because he resented the student accusing him of something he did not do and felt was completely misaligned with his values and behaviour as a teacher. Alex chose to explicitly communicate this emotion-related information to the whole student cohort by email, along with his response:

"I find it disheartening, mildly offensive and rude to suggest I am deliberately making this harder than it needs to be. This couldn't be further from the truth. I completely empathise that this situation is shit, but try and have some empathy for those on the receiving ends of comments because some of us do care. Despite this, I am incredibly proud of how the majority

of you have taken the time and effort to really engage in the statistics sessions and it's been great to teach in-person again!" (Alex, LS).

Here, Alex described using a cognitive change interpersonal ER strategy to encourage students to reappraise the situation, taking into account his perspective, their shared educational goal and progress towards it. As a result, he received emails from students expressing convergence of annoyance towards their peer and appreciation towards his teaching. I would suggest that this is a more extreme example of emotion socialisation.

Teacher data included examples of emotional *divergence*, for example when students expressed frustration about lack of opportunities for applying their knowledge or non-contributing peers and teachers expressed a *complementary* emotional reaction such as disappointment with colleagues or students. A rare example of *divergent, conflicting* emotion was shared by Jessica who responded with anger to other university teachers' enjoyment over students' mistakes:

"it's come to that point again in the year when I become furious on Twitter about people sharing their hilarious student essay mistakes, about how shit the essay was that their student has written which every year enrages me because it's just so unprofessional and thoughtless" (Jessica, MD).

Some teachers referred to being on the receiving end of *collective emotions* as James illustrates: "Some of the emails we get are from confused and angry students. They've chatted and they've decided" (James, MD). The macrolevel affective phenomena of *collective emotion* emerges when multiple socialising agents are responding to the same situation, interacting and, as a result of emotional contagion or motivation to communicate about their emotions, collectively experience an emotion that is greater in magnitude and duration than those experienced individually (Goldenberg et al., 2020). James was referring to collective emotions created between students as they undergo and make meaning of assessment experiences together. Such emotional information is worth teachers addressing, because, as Vivek notes, it can lead to emotions that would not otherwise be experienced by individuals:

"What happens with this initial critical mass, if everyone feels frustrated and are...reacting to it negatively, possibly the other students want to join the boat and just react similarly, rather than what they would do as an individual" (Vivek, MD).

8.5 Teachers regulating emotion in collaborative, active learning

Having considered individual's awareness of how emotion is perceived and understood in STEMM classrooms, and how these processes contribute to constructing emotion, in the following section, I illustrate how teachers appeared to use this information consciously and unconsciously to guide their practice. To inform this analysis, I again applied the lens of Gross' (2015) 'Process model of ER'. The examples presented below are both illustrative of strategies across the teacher dataset and highlight complexities of ER in the context of university teaching and learning.

8.5.1 Situation selection

Based on their experience-informed predictions about emotion in given educational contexts, and their beliefs about the desirability and undesirability of emotions for this learning, teachers demonstrated using situation selection strategies. These included choosing to approach or avoid situations and varied between teachers and contexts. Teachers readily gave examples of selecting content and learning methods, planning timings, arranging learning spaces, organising student groupings and designing assessment that took into account anticipated emotion. Situation selection is the most forward-looking strategy (Gross, 2015) and, I suggest, can extend from the programme design phase to the moment students engage. Given the complexity of university STEMM learning, student variability and humans' known inaccuracy in predicting even their own emotions (Wilson and Gilbert, 2003), this is difficult for teachers to judge with accuracy (Sutton, 2004). In this case, maybe the goal should not be accurate anticipation, but rather that situation selection informs educational design that anticipates and supports emotions responsively.

In terms of selecting content, further to discussion about the relative value of knowledge in Chapter 5, giving the rationale for content selection was considered to upregulate positive emotion. For example, Jessica highlighted how, when content choice was framed in terms of a teacher's emotional engagement with it, this could promote interest and curiosity:

“[students] definitely perk up if suddenly their lecturers say, ‘Well, I found this interesting, or what I found really interesting about this, or my reaction to this was this’... There’s a different debate, I guess, about how appropriate, or not, it is to expect teachers to divulge things about themselves or to share their impressions...But I think that that is the thing that seems to make them, sort of, infectious curiosity” (Jessica, MD).

Her questioning of whether teachers should be expected to share their emotional responses to teaching material resonates with concerns about teachers being required to be 'more authentic' or even to show vulnerability (Molloy and Bearman, 2019).

Preparing students was another identifiable focus of situation selection strategies. A common feature of active learning is the need for students to come prepared to engage actively. Flipped learning is intended to empower students by equipping them with knowledge in advance. This should promote self-efficacy and reduce anxiety and so, I suggest, can be seen as a situation selection ER strategy. Conversely, Ina alludes to the emotional challenges created by students failing to prepare for Chemistry labs and what can be done to anticipate and avoid this eventuality by using negative activating emotion (Pekrun, 2006) to motivate students:

"they need to do a decent amount of preparation, which isn't always the case. If you arrive having no idea what you're doing, because you've not even read the script. Problem. I guess you've got to balance those two things. You've got to scare them enough that they do some preparation but not scare them too much" (Ina, CH).

Active learning relies on teacher and learner cooperation to be successful. Teachers need to be able to trust students to play their part and this can feel risky for many who fear a stressful loss of control and sharing of stress when students cannot engage in active learning as intended.

How groupwork was selected for and designed was an important example of situation selection strategy. Teachers discussed group size and composition, self-selection versus teacher-selection and duration and timing of group working. Here, Kris describes an unorthodox approach, basing group allocation on previous peer assessment scores, that he took to avoid anticipated negative emotion and promote positive emotion:

"High engagers...want to engage with the course, so I need to put them together to prevent conflict. And people who, um, do not want to engage with the course I put them together, and then they could be happy" (Kris, ME).

Scheduling, particularly of assessment, could be considered another situation selection strategy. Batman described: "looking at the timetable...to make sure that no student will have two hand-ins in the same week" (Batman, ME). But does this hedonic goal to down-regulate negative emotion remove the need and opportunity for

students to learn to manage the pressure of conflicting deadlines? I will return to this dilemma.

8.5.2 Situation modification

Situation modification was recognised as teachers describing actively changing a situation in order to modify its emotional impact (Gross, 2015) which, in an educational context, can sometimes be difficult to distinguish from situation selection (Sutton, 2004). In my analysis, I judged situation modification as what teachers described changing during and between sessions, as they seemed to become aware of emotion and formed an ER goal. Across the dataset, teachers described using situation modification strategies related to pacing content delivery, giving explanations, and asking and answering questions.

For example, Andrea described using questioning as a tool to perceive, understand and regulate students' emotional responses to her biological explanations, in real time:

“you use your questioning to find out who's with you and who isn't...you stop occasionally and say, you know, ‘does everyone get this point? I'm happy to stop here, there's time’...Some students will raise their hand [to ask a question]” (Andrea, LS).

Although she does not unpack the full extent of her goal, beyond allowing students to ask questions to enable themselves to ‘catch up’, and does not describe it as ER, depending on the student, her questioning may be upregulating positive emotion, in those who understand, and possibly downregulating positive emotion of those who do not. I say possibly, because even if a student does not yet understand this point, if they feel intrinsically motivated and have a mastery orientation, the question may spark curiosity and a desire to know more, and they will experience positive emotional upregulation. Those who raise their hand will likely have weighed up the emotional risk versus benefit of this decision and it may be through a desire to upregulate their own or Andrea's emotion, who has explicitly said she is happy to stop for questions.

James talked about using student question-asking, in a way that leveraged the ‘zone of optimal confusion’ (D'Mello and Graesser, 2014), by upregulating, then downregulating confusion to motivate learning:

“we're incredibly responsive to that confusion. So if that confusion is supported and you're dealing with that confusion as it arises, then actually, that confusion becomes positive and activating. I'm confused, I ask a question, it gets replied, I understand” (James, MD).

Teachers often talked about using ER strategies in combination, although they never used the term ER. James and his team described using combined situation selection and modification ER strategies to enable students to challenge the accuracy of TBL assessment questions and answers:

“they are allowed to submit challenges for any questions we write. And then we review those, and then we relay that back to them. You know ‘we’ve accepted this challenge because’, ‘we didn’t accept that challenge because’ so that they know that if they think something’s unfair, you know, we will listen and respond” (James, MD).

In response to student challenges, teachers modify the situation to regulate student emotion by addressing perceived unfairness and they believe this contributes to building trusting pedagogic relationships. As James continued to explain, his educational design also attempted to extrinsically regulate his tutor colleagues’ emotions and intrinsically regulate his own, in the face of challenging teaching:

“to expect one person to comfortably handle the nuance of each question, particularly when, you know, in trying to write challenging questions, you know, we’re not always getting it bang on perfect. So it’s very uncomfortable to put a tutor in that position of trying to determine whether a question’s fair or not, whether there’s an easy answer, or whether it’s more complex, so, I think it was a practical decision” (James, MD).

Possibly not surprisingly for technically-minded STEMM teachers, making modifications that would impact on how students felt about learning tended to be framed as practical decision-making. Kris, expressed how he valued interaction with students doing their design projects and being able to make real time decisions that signalled collaboration with students:

“I think it’s actually good that I walk around and ask them, ‘Can I help you guys?’...I can take the ‘on the spot’ decisions when they ask something. ‘Ok, yeah, that doesn’t work in this project. Let’s make a decision here and now.’ Which I do all the time” (Kris, ME).

The use of peer assessment in this same project again illustrated how university teachers deploy situation selection (through educational design) and modification (through facilitation) in interacting ways in university curricula to regulate emotion:

“we use peer assessments twice during the project. So once, once midway through the projects and that’s completely formative... If the issues are

serious, then the tutor's asked to step in, and at least trigger a discussion with the group, and that's focused on how can we fix it. And then the one at the end of term counts for real and also is used to adjust the mark" (Kris, ME).

In this way he demonstrated how different strategies are used to address different goals, although this was not necessarily articulated as an emotion-related goal to himself or the team before my research intervention. Key to regulating emotion in this context seemed to be the teaching team's ability to demonstrate to students their responsiveness, such that students feel their emotions have been taken into account. Kris frames this as a problem fixing approach rather than an opportunity for emotion socialisation. Is this a missed opportunity for explicitly developing emotional literacy, or a supportive approach that is sensitive to traditional disciplinary culture?

8.5.3 Attentional deployment

Notably, I did not identify examples of teachers referring to using the more perception-based strategy of attentional deployment as an extrinsic interpersonal ER strategy, in terms of attracting or diverting students' attention towards or away from the situation. As demonstrated earlier, students did describe using this strategy for themselves, so possibly at this age and stage learners are expected to manage this themselves. It may also be that attentional deployment is fleeting, subtle and often intertwined with other interpersonal ER strategies, making it less memorable and therefore less influential in informing teachers' retrospective accounts. Certainly, when teaching, I have noticed myself moving collective attention on when students appear bored of specific content or ideas, and also diverting my own attention away from perceptibly bored-looking faces to smiling ones in order to up-regulate my own emotion, mid-session.

8.5.4 Cognitive change

Cognitive change is considered to be the most effective family of ER strategies (Taxer and Gross, 2018) and refers to changing the emotional impact of a situation by changing one's appraisal, thus it is also known as reappraisal or reframing. Some teachers described skilful use of cognitive change that took into account a number of factors that they knew would be salient in their context.

In a context characterised by high academic expectations, the need to manage these was considered important. For example, Alex described attempting to challenge his students' high expectations of themselves as science learners and to reframe these by highlighting the

relative difficulty of the challenge. He likened programme language learning from scratch to foreign language learning:

“I try and give them a lot of analogies around learning programming and thinking about, you know, if you were to learn a language from scratch, what would your expectations of yourself be? ...All that they see is, this is biology and this is statistics...that I should be good at. But actually, if you relate it to something that's not STEM and not science, I think some of them can say... '[if] I was learning French for a few weeks, I might be happy with saying, 'Hello, how are you'? (Alex, LS).

A representative quote from one of Alex's students suggested that such strategies were supporting them to reappraise what they are capable of and supporting their development at both cognitive and emotional levels: “This stats module is demystifying the programming world and makes me feel like I am capable of smthg i didn't expect” (Student83, LS).

Similarly, Ina described trying to encourage students to see the situation from a different perspective, this time encouraging them to be more self-compassionate by seeing their academic struggles through their peers' eyes:

“If you point out to them, 'would you judge someone who's struggling with something? Well do you talk to your peers?' 'I don't, because I'm scared they will judge me.' If you point out to them if the situation was reversed, would you judge your peers and they will go 'well, no, of course not.' 'So why do you assume that they will be judging you?' (Ina, CH).

Finally, William described how he encouraged students to reframe by critically reflecting on their actual experiences, with the apparent goal of down regulating their annoyance or anxiety. In this way, his longer term goal may have been to adjust their attributions, including locus of control, and take responsibility for their learning and time management:

“I had third years complaining at me, it's like, 'oh, but last year, the spring term was the worst term of my life because Design...' 'How much time did you actually work on it? Did you start really sort of towards the end of term?' 'Well, yeah.' 'So?' (William, ME).

8.5.5 Response modulation

Response modulation is the only family of ER strategies that occurs after the emotional experience. It involves the individual altering the physiological, experienced or expressed

element of the emotional response (Gross, 2015). This includes expressive suppression (when an emotion is felt but not expressed), faking (by expressing an unfeared emotion), and masking (by expressing a different emotion to the one felt) (Taxes and Gross, 2018). In line with literature (Frenzel, 2014), the emotion teacher participants felt it was most beneficial to express enthusiasm, and occasionally this involved faking. For example, Hemal explained that when he felt less enthusiastic, typically because someone else had prepared the material, he deliberately made “an effort to make it somewhat of a stage performance to be always enthusiastic” (Hemal, PH).

Several teachers’ instinctive response was that they should suppress and not show negative emotion to students. It is well documented that suppression of emotion is not healthy for emotional or physical wellbeing, owing to the physical strain that it can put on the central nervous system, and is a significant contributor to emotional labour (Taxes and Gross, 2018). Many teachers expressed annoyance and frustration at student behaviour but it was unclear to what extent they expressed this to students, as anger can be considered a taboo emotion amongst teachers (Frenzel et al., 2021). However, expressed negative emotion may be an important form of information for students that they need to prompt change in their behaviour, increased effort or use of recommended approaches. This is a significant decision for teachers and can be risky, as Alex illustrated when recalling a lecture:

Alex: “For me it can be very frustrating because I can see other people really trying and really excelling and then you might have a group of people that are talking amongst themselves and giggling...sometimes I have to stop myself from just being like, ‘well, if you just focused, you might actually get this.’ You know, and I’m like, should I say this? Should I not?...Inside, I’m quite frustrated...One time where I was like, ‘If you just stopped and listened, you might actually get this.’ Or I have called people out in a lecture, being like, “Do you want to come and teach this instead?”

Andrea: “Oh, that’s a good one!”

Alex: “At the moment, it wasn’t the best thing to do.”

Alex’s approach sounds reasonable, and he did not explain why he judged ‘it wasn’t the best thing to do’. I suggest this serves to highlight a challenging aspect of university teaching around behaviour management, on which we get little feedback and support to inform approaches. This lack of transparency may be a reason why many teachers reported feeling and thinking about, but aiming not to express, frustration and annoyance. Had I interviewed individual teachers, they may have given different responses. Interestingly, Alex’s honest

reflections resonated with Andrea in way she found useful, indicating valuable emotion socialisation through the focus group interview process.

Many student responses indicated they were aware of teachers' emotions, but it was usually unclear whether they perceived them based on emotional expression, or inferred them based on context. Student66 suggested Alex was masking, based on the student's inference: "I think they might be a bit bored of teaching the session as they already conducted the same class before mine, however they did not show it as they conducted the class enthusiastically" (Student66, LS).

It may be that some teachers do not express emotion because they are good at regulating it earlier in the ER process. In the same way as students, teachers also described using emotion-focussed and problem-focussed coping, or taking action to address the problem (Folkman, 2013). George demonstrated awareness of how he cycles through both approaches: "what happens is that you get a complaint, you get upset about it, but then you think about it, and then you will do some improvement, that's usually what happens" (George, EEE). He demonstrated using cognitive change and situation selection or modification in combination to regulate his emotion.

8.5.6 Collaboratively regulating emotion

As hoped, it was advantageous to interview trios of teachers because the conversations between them gave insight into how they regulate each other's emotion around teaching, both during the interview and more generally. In some cases, it seemed that the interview itself had prompted an important emotional interaction. Where there was a strong sense of taking a team approach to educational decision-making, this seemed to contribute to interpersonal ER, as Hamza illustrates, when describing parallel teaching of seminars by different tutors:

"it's not the case that we have to cover everything...we try to keep that relaxed environment during the seminar. We are not pushing to finish the stuff that we have, when we see that oh, during this topic, students...are enthusiastic to talk or they want to engage. So we spend more time on that part... We are not worried at all there is something that we are missing" (Hamza, PH).

This agreement seemed to remove teacher discomfort about not 'covering' or 'missing' prescribed material, allowing a more flexible approach, that paid attention to and guided the session according to perceived learner emotions. This is important because in STEMM

curricula, with a strong traditional goal of 'covering' key content, the freedom to be more responsive comes with risks and it seems helpful to share these risks.

For aspects of the curriculum where being particularly emotionally sensitive was important, some colleagues talked about working together. For example, Jessica and Erica reported taking pride in developing emotional competency together when giving feedback on an unfamiliar and innovative visual-based assessment:

Jessica: "Me and Erica are like the masters of constructive feedback..."

Erica: "It was kind of fun doing it because you're trying to find tactful ways. 'Ok, yeh, no. Don't ever do that again!' Um, but also to be encouraging to them, to find some of the good things they did" (Jessica and Erica, MD).

The data also included a few examples of teachers explicitly describing how they regulated each other's emotion. For example, George described using cognitive change strategy to help a fellow teacher gain perspective when interpreting student evaluation of teaching:

"every time she received...a couple of negative comments she gets very negative and gloomy and I tell her 'but how many students do you have?'. '140'. So that is just noise. It's irrelevant, you know" (George, EEE).

In this section I have illustrated that even teachers who are not consciously aware of ER strategies use them in ways that are integrated into educational decision-making at every stage of the teaching process. Based on my analysis, I suggest that, in busy and diverse classroom contexts, interpersonal ER goals should not aim to provoke or avoid the same emotions in all students, but should demonstrate awareness of emotional possibilities at planning stages and responsive attention-paying during facilitation, and enable students to better regulate their own emotion, as I have illustrated many are already doing.

8.6 Constructing empathic goals in STEMM learning and teaching

Having considered how the first two components of empathy, emotional experience sharing and cognitive perspective taking can be characterised in STEMM university classrooms, I will focus on the third, prosocial action element that I suggest is the most complex, owing to the nature of goal achievement in educational settings. In some ways, I have already begun to illustrate this, through teachers' descriptions of goals and approaches to regulate students' emotions in the process of teaching. However, as introduced in the Theoretical Framework chapter (see p51), the concept of empathic concern, that involves individuals

feeling proactively motivated to help others to improve their wellbeing (Zaki, 2020) is helpful for looking more critically at how wellbeing can be supported in high pressure, academic contexts. Applied to this study's context and data, Zaki's (2020) examination of the interconnections between different components of empathy and ER can help us to understand how different teachers, and in different situations, respond differentially to student emotion. I suggest that on this data-informed, theorised basis, we can critically evaluate which approaches may be particularly beneficial for teaching, learning and wellbeing. If the previous section, *8.5 Teachers regulating emotion in collaborative, active learning*, is reconsidered through the lens of extrinsic and intrinsic ER, it is evident that many examples relate to teachers attempting to reduce students' emotional discomfort (extrinsic interpersonal ER) but also avoid teachers' own emotional discomfort (intrinsic interpersonal ER), including stress that they may have previously felt through experience sharing in pressurised classroom situations. Although in theory they are considered distinct, with distinct empathic goals (Zaki, 2020), in the reality of this context, intrinsic and extrinsic ER they are intertwined. Participant George illustrated this well. His approach of delegating project proposal selection and peer feedback to students could be interpreted as motivated by an *intrinsic* ER goal, to avoid him "feeling scared" about student complaints on social media and to "avoid the drama" of groupwork. However, his situation selection strategy also aimed to empower "shyer" students and enable groups to develop more ambitious projects that they could be collectively proud of. I interpret these as *extrinsic* ER goals to improve students' learning and wellbeing. By applying Zaki's framework (2020), I argue that George demonstrated moving skilfully between intrinsic and extrinsic ER, taking prosocial actions to regulate students' emotions, as well as his own. I suggest that this empathetic, but boundaried, approach was protective of him and provided opportunities for his students to learn to work with emotion. He later highlighted the emotional burden that can be felt by university teachers, and that make boundaries important: "as year organiser, I'm in various...departmental committees, subcommittees...and I'm actually tired, psychologically tired, of dealing with this stuff" (George, EEE). Brown (2021) argues that boundaries are a pre-requisite of being empathetic. Ina also indicated being mindful of this in her practice: "You have to consider the stress of talking to a student about stress!" (Ina, CH). The following quote from Hemal demonstrates how he recognised the intrinsic, as well as the extrinsic, function of the cognitive change ER strategy he described deploying at the beginning of seminars: "One thing I say every time, it's partly for my benefit, so I feel at ease, is I emphasise to the students what a nice, relaxed session it's going to...and it is." (Hemal, Physics). These examples from teacher data resonate with Thompson et al.'s (2019) assertion that a fundamental connection between the traditionally, conceptually divided

constructs of empathy and ER is that the emotional state provoked in the observer as they empathise can be subject to ER.

Through this lens that combines empathy and ER, we can analyse in more nuanced ways the challenges for teachers attempting to balance extrinsic ER goals and strategies to support student wellbeing, with academic goals related to learning complex knowledge and developing difficult skills. Whilst, at the same time, they need to pay sufficient attention to intrinsic ER for the sake of their own and other teachers' work-life balance and sustainability of practice.

8.6.1 Relational facilitators and barriers to empathy

Teacher and student data revealed a bidirectional relationship between pedagogic relationships and empathy, and this was mediated by individual's goals. First, teachers felt better able to perceive and understand a cohort's emotional experiences and felt prosocial motivation for supporting their learning and wellbeing if they could develop a relationship. Second, a willingness to recognise and respond to emotion was seen as conducive to positive relationships. As Ran et al. (2021) assert "expressing empathy is a prosocial way of fulfilling one's goal of maintaining an interpersonal relationship" (p451). The teachers generally viewed building relationships with students as an important pedagogic goal. As Victoria illustrates, they described how simple techniques gave a clear indication of empathy, that they were aware students appreciated:

"whenever they raise their hand to make a contribution I ask them what their name is. And then I say...by the end of the year, I'll try and remember, you know, 80% of your names... They say they value the fact that...I made an effort, that I tried to get to know them. They can see I love teaching. And I smile. And I appear human" (Victoria, EEE).

In large and growing cohorts, the avoidance of dehumanising learners and teachers is a key goal of relational pedagogy, and emotions are seen as key to relationships (Bovill, 2020). As Quinlan (2016) explains, "emotion matters in higher education because education is relational, and emotions are central to relationships" (p102). However, Antonia highlighted how staffing a large cohort of 350 medical students can sometimes inhibit more aspirational relational goals: "we can't have as many tutors as would make that work well...So there are real tensions in terms of delivering what we believe is important for their learning and development" (Antonia, MD). Her colleague, Erica, flagged the lack of consistency and regularity in teacher-student interactions and the challenge this poses for genuine

empathetic interactions and rewarding relationships: “if I saw the same students over and over, that would give us more of a chance because you go in cold and you teach, but by the end of the session, you feel like you do have a relationship” (Erica, MD). James reinforced this sentiment, expressing strong positive emotion when talking about his experience of regular, in-person TBL teaching in active learning settings: “we’re kind of bouncing around the tables and checking understanding and chatting to them and all the rest of it, so you can get...to know students a bit better” (James, MD).

Jessica described how interactions through active learning can enable meaningful and supportive one-to-one relationships to develop, especially where there may be a shared emotional connection, as well as a shared academic interest. Jessica’s quote highlights both the value of this connection, but also the importance of maintaining boundaries:

“they feel quite, more comfortable speaking to you about, because you have made it clear that you study this area, and to some of them that you have personal experience of some mental health issues, and so you become a person who is seen as very safe to approach and, to some extent, that’s fine” (Jessica, MD).

As illustrated earlier, student data demonstrated that they generally highly valued the peer relationships that interactive, student-centred approaches characteristic of active, collaborative learning bring. Through my study, I have become convinced that student project groups should be kept more consistent and allowed more time to develop trust and emotional connection, as this is valuable for peer learning and wellbeing, as Student187 explains:

“My peers handle their work pretty well, so more than anything I felt like I can trust them and their abilities. They help dampen my insecurities and stress...I am prone to mental health issues, so any excess stress can tip me over the edge, leading me to a totally shutdown. During this week, I have been getting better at handling this...the big stress is balanced out by the friendships made during this experience” (Student187, ME).

William highlighted the emotional tension created in university teacher-student relationships by teachers occupying multiple educational roles:

“there’s this worry that the supervisor is also the assessor...So, you get...this sort of weird disconnect... ‘Do we do we treat our supervisor carefully because they’re gonna be assessing us? Or do we accept the

fact that our assessor is actually going to be quite positive towards us because they already know what we've done?' And it's very difficult to work out whether that's a good thing or a bad thing" (William, ME).

This could be interpreted in terms of the way we adjust our goals and emotional orientations towards an event (Parkinson, 2019), such as assessment, as we switch between these roles. As supervisors, our goals include developing students' understanding and problem-solving approaches and are likely aligned with learners' goals. As assessors, goals become about judging students' academic work against a standard. This shift can affect student perceptions and interpersonal emotional influence (ibid). Students may not be aware of what teacher-assessors' goals are regarding assessment. Indeed, how explicit are assessors about this within marking teams? Are our goals to be fair, objective, to meet a quota, to discriminate between work, to encourage collaboration, to aid development, to reward subjectivity, curiosity, creativity? In reality, in our assessor roles alone we have multiple goals, some of which are conflicting and uncomfortable to reconcile even for us.

Several students in the mechanical engineering cohort commented on this tension and confusion, with one responding: "My tutor is [William], who is known for being a very harsh marker. This mildly terrifies me as I think he likes our group and designs but there is no way of telling, which is quite scary" (Student173, ME).

Again, this illustrates the dynamic and contradictory nature of emotion in learning and how the language that we use socially constructs both emotional experience and meaning in academic contexts. Why is this student "mildly terrified"? Is it the lack of control because there is "no way of telling" whether the positive emotion they infer from interactions with William will translate into good marks? Does William being regarded as a harsh marker make him liking the group and design more valuable, especially if the mark he gives is judged to meet or exceed the group's expectations of themselves? Is it in students' interest to perpetuate this "harsh" reputation?

8.6.2 Lack of empathy

Empathy is often considered from the perspective of the empathiser, but in order to be successful it needs to be recognised and felt, as well as given. The data gave interesting insights into what various socialising agents judged to feel like a lack of empathy. Empathic concern and ER can involve multistep forecasting which involves judging how future events will affect the emotional experiences of others and self, and how emotions will affect events (Zaki, 2020). For example, in advance of an assessment a teacher judges whether it is most

helpful to reassure students they are well prepared and upregulate positive emotion, or to advise them how to prepare more, potentially upregulating negative emotion, in the hope that this will motivate students to revise. Such data as gathered in this study could help make these calculations more accurate.

Interesting conversations during teacher focus group interviews demonstrated them constructing meaning around empathising and how this could be better understood and refined. For example, several mechanical engineering students fed back that a source of negative emotion came from teachers not empathising with regards the challenges of Design Week, for example: “Teacher comes across likes everything is simple and easy which makes it worse” (Student178, ME). Batman noticed this in the students’ survey responses and instinctively empathised with students and teachers, prompting Kris to critically reflect on his practice and possible impact on learners:

Batman: “I think it might just come across as the tutor trying to be reassuring. And then it's being perceived as too reassuring.”

Kris: “I agree. It's probably something I do as well... ‘Guys, like this is not difficult. Just let's step go through it’. But indeed, on the receiving end of it...you've asked a question because you think it's really difficult. So someone telling you it's easy, it really, well it's rather useless...So yeah, I can imagine that that's actually really not a good approach.”

Similarly, colleagues in Physics considered how they demonstrate empathy when reflecting on how to support students with learning complex concepts:

Hamza: “I try not to do that because then I think, it's like ‘Oh if the lecturer finds it hard, then I'm never gonna be able to do it’.”

Sophie: “I say, ‘this is really difficult and when I was your age I found it hard. But you know, you can do it’. Like, I don't ever say, ‘you're not going to understand this’ or whatever.”

Hemal: “Yeah, I'm with Sophie...I'd never say ‘you're never going to, this is really difficult and you'll really struggle to understand it’.”

In both conversations, participants move between students’, their own (as learners and teachers) and other teachers’ experiences and perspectives, weighing up educational and emotional goals and using these to attempt multistep emotional forecasting. Note that in no interviews, nor any student questionnaire were the words *empathy* or *empathetic* mentioned. Generally, expectations that empathy should be, and often is, somehow embedded in university teaching and learning are evident yet tacit. This means that there is a lack of

shared understanding about what makes pedagogic empathy recognisable, effective and appreciated.

Examples of a perceived lack of empathy in student data included lack of availability, interest or willingness to talk about emotional experiences, as the following quotes illustrate: “Hard to talk to them how we are feeling, but vague answers to problems increase stress” (Student157, ME).

“It feels like he’s quite distant and very busy from every individual. Seemed difficult to reach out to him even when I was struggling” (Student182, ME).

Student182’s quote may refer to a teacher using a situation selection ER strategy to avoid associated emotional ‘hassle’, or it may be due to other goals and priorities, or both.

Certainly, teachers in this study demonstrated varied yet strong interpersonal ER and empathy in many elements of their professional practice and it is interesting to think about how these develop. As Hubert highlights, teachers may not necessarily have had been socialised in this way or had role models who helped them to develop effective strategies:

“I can remember many teachers in my life that were, you know, like these entities that didn’t have any kind of visible feelings...so for me, it’s an insane idea talking with a teacher with, about how they feel or how I feel” (Hubert, CH).

8.7 Reframing empathy for higher education contexts

Data discussed has demonstrated that various types of empathy was evident in interactions between STEMM university teachers and student peers, and that both use a number of intrapersonal and interpersonal ER strategies, including to achieve extrinsic and intrinsic ER goals. Next, I examine the insights data gave into socially constructed understandings of empathy in these STEMM learning contexts and draw on theoretical perspectives to critically consider how helpful these are, given HE goals, including for transformative learning. I consider how this may mean that teachers’ goals for students do not necessarily match students’ goals for themselves and the implications of this for intended and perceived empathy.

8.7.1 Counter-hedonic interpersonal emotion regulation

As data presented so far has illustrated, ER goals often involved wanting to up-regulate positive emotion, down-regulate negative emotion or change an unpleasant emotion to a

pleasant, positively valenced emotion. Such hedonic goals are often assumed to be the way to improve someone's wellbeing (Niven et al., 2012, Zaki, 2020) and this is a prevalent belief amongst teachers (Frenzel et al., 2021). However, individuals have a variety of counter-hedonic motives for up-regulating unpleasant emotions both for themselves (Tamir, 2016) and when seeking to influence the emotions and behaviour of other people (Zaki, 2020).

Several participating teachers described deploying what I interpret as counter-hedonic interpersonal ER in an attempt to change learner behaviour when they did not feel that students were putting in enough effort, or to challenge confidence-related beliefs. They discussed weighing up how to tailor this to the situation, choosing between hedonic and counter-hedonic interpersonal ER, as Ironman illustrates:

"So the way I use emotion during tutorials is I try to push them further and further to see their response. If they have low confidence and they are uncertain, then I give a bit of a pat on the back. 'That's good work, carry on, keep it up' and so on. If they are more confident, perhaps a bit cocky, then I challenge them further and further, until they realise, 'oh, that can be more than I could do'. And that's how I try to use the emotion, so they learn more" (Ironman, ME).

Having made a conscious decision to deploy counter-hedonic interpersonal ER, it can be difficult for teachers to get feedback on whether it had the desired effect. In this quote, William describes a situation where he expressed frustration at a student's lack of innovation or creativity in response to an assessment brief to design a hand tool:

"Periodically, you would come across [a student] and he'd say, 'I'm gonna do a brush' and it's like 'That's a bit rubbish, isn't it? Can't you think of something a bit better'. And they'll go away and they'll come back and say... 'I was chatting to this person, chatting to that', and they're really enthused, and they've got real interest. And that's fantastic. But it doesn't happen that often, unfortunately. Sorry, Kris" (William, ME).

A way to interpret this is that, through multistep forecasting, William judged the interaction between emotion and future events. I suggest that he chose to express frustration and disappointment and this up-regulated the student's negative emotion and motivated them to engage with others to learn more. William's perspective is that this ultimately resulted in up-regulation of positive emotion for the student and William. It aligns with Frenzel et al.'s (2021) observation that teacher annoyance can be perceived by learners as reflecting belief

in their ability to perform better. Notably, William acknowledges that his evaluation may have influenced Kris, his colleague's, emotion.

Often examples of counter-hedonic interpersonal ER were less direct than a teacher intentionally attempting to influence students' emotions, but rather related to teachers preventing themselves from intervening to make students feel better. By setting tasks that students find challenging, teachers anticipated that they may increase many students' negative affect. Their hope was that this would drive students to realise meaningful goals and build self-efficacy. A potential concern is that counter-hedonic interpersonal ER, as an educational approach, creates tension in student-teacher relationships. However, it is important to acknowledge that as 'emotional pragmatists' (Zaki, 2020) many students do not have purely hedonic goals for themselves. This was evidenced by the high number of student respondents who, even when reporting experiencing negative emotion, recognised that this had a motivating effect on their learning. Individuals, especially adolescents (Riediger et al., 2009) present in these UG cohorts, may have varying counter-hedonic motives, including managing how others see them, cultural values and achievement goals (Zaki, 2020). Student172 who described feeling both "Stressed and energetic" seemed to recognise that teachers created this stressful situation to ultimately enable achievement and positive emotion: "[Teachers] create it. By setting deadlines that are slightly shorter than the time needed for tasks, they push us to work harder and maybe even surprise ourselves" (Student172, ME).

As discussed in Chapter 5, an important and challenging goal in contemporary STEMM education is enabling students to learn from mistakes (Lanni, 2021). William described how this was carefully facilitated in a way that could be understood through the lens of balancing counter-hedonic and hedonic interpersonal ER:

"some aspects of it are set up to allow them to make the obvious mistakes, to learn from those obvious mistakes, but as tutors we're instructed to keep an eye on these things and make sure they don't go too far" (William, ME).

There is a risk that counter-hedonic strategies used to achieve mutually beneficial goals, like students becoming more independent, may negatively impact on a teacher's identity goals, such as being seen as a supportive teacher, as Kris reflected:

"one of the [student] feedbacks that I got two years ago, which still hurts, was indeed that sometimes I was a little bit too cynical when students asked me what I classify as a stupid question... and the students didn't

really like that...So I think everyone has their own style and we adjust it continuously based on the feedback we get from the students...and based on what we see works and doesn't work" (Kris, ME).

This quote illustrates how generating negative emotions in others can lead to a need to accept negative emotion personally, and for self-regulation (Zaki, 2020). As Kris reasons, this aspect of teaching practice can be managed through continuous reflection on experience and student feedback. Erica also recognised the emotional and relational challenge that this can present, especially when trust is important for relationship building, and the importance of students being aware of educational value of 'struggle' that their teachers appear to create:

"if they just think we're leading them to struggle, that that's a horrible view of us, of what we're trying to do. If they understand that...if you work on it, and tussle it out in your own head, you'll learn so much more by doing it" (Erica, MD).

This conflict was also expressed by Hemal who described students asking him, "Do you really deliberately confuse us?" and although his belief is that confusion is important in learning Physics, he found the conversation uncomfortable. Given that counter-hedonic interpersonal ER may be counterintuitive and uncomfortable for teachers, this study's data is valuable for considering how it works in practice. I suggest that this is an aspect of practice that could be better supported, including through more explicit and theoretically-informed discussion about how to work with difficult emotion and facilitate emotion socialisation between teachers. Putwain et. al's (2016) research on the effect of fear appeals offers a valuable word of caution. Fear appeals are messages that teachers may communicate to highlight longer-term negative consequences, for example of not studying for important assessments, in order to motivate learners to study. Putwain et al. (2016) highlight that the same fear appeal will have different impacts on different students' motivation, affect and performance, depending on whether they interpret the message as a threat appraisal, when they anticipate failure, or a challenge appraisal, if they value attainment and anticipate success. In line with this present study, they foreground the importance of fostering trusting student-teacher relationships, so that any such use of motivational messages can be contextually judged (Putwain et al., 2016). Participants did not refer to fear appeals being used but differential interpretation of threat and challenge appraisals may still be relevant.

There were also examples of counter-hedonic interpersonal ER between student peers. Student169, quoted below, indicated their awareness of how up-regulation of positive emotion associated with caring may inevitably be accompanied by up-regulation of negative

emotion such as stress, both of which indicate the goal's importance: "It feels right to apply our knowledge to an actual project we care about...I talk about the project outside of designated hours... [Peers feel] Stress as it's been the major subject of discussion" (Student169, ME). They also acknowledged that this feeling of stress may partly be socially constructed through peer-to-peer conversation. Student43, quoted below, seemed to blame themselves for causing arguments, but it could be interpreted that their irritability was an important source of emotion information and a form of counter-hedonic interpersonal ER that peers should have paid attention to in order to redirect their goals:

"Some students have been over-ambitious and set unrealistic targets and then not helped achieve those targets. My stress has led me to be irritable and have arguments with the group, creating a vicious cycle (Student43, EEE).

8.7.2 Cooperation: emotionally connecting over goals

Central to empathy is human beings' ability to understand other people's experiences, and their desire to infer how others might be feeling and how they can help. As Zaki (2020) critically observes, much lab-based psychological research into empathy assumes that observers that demonstrate empathy have *cooperative* extrinsic interpersonal ER goals that are in alignment with a target's goals. He argues that this fails to consider the larger range of empathic motives and goals in the real world where "inferences allow observers to negotiate and cooperate by pinpointing targets' goals even when they differ from the observer's own goals and by helping targets achieve their aims" (Zaki, 2020, p522). Here, I will present evidence of this cooperation in the data, which is considered to be preferable to noncooperative interpersonal ER goals associated with paternalism, that can be motivated by empathy to protect students' feelings (Lupoli et al., 2017). There is an overlap with counter-hedonic and cooperative goals (Zaki, 2020).

Teachers in the study sometimes described using inference to identify students' goals and also commented that students' beliefs and goals differed from their own. In the following quote, Hubert seems to doubt the validity of this inference approach to empathising, even though it is probably instinctive:

"I would say that they stress about whether they will be able to kind of come up to...the level of the challenge or whether you will be able to, to cope with it or not. But...that's pretty much, from kind of, like from what I *think* they would feel" (Hubert, CH).

As a teacher he describes having different goals, including that students enjoy their learning and take creative risks, yet he understands that the students' goal may be to cope with the level of challenge and associated stress. His switching between 'they' and 'you' suggested this may have been based on his own experiences. Hemal expressed surprise that his use of a concept map, with a goal of supporting students to begin collaboratively consolidating and revising, had caused stress. He demonstrated using cooperative empathy to try to understand how students might feel:

"I'm trying to think what I'd ask a student to try and pinpoint that...I wonder how I think I would have felt if I was in that position, because I, you know, like most humans, I tended, tended to get a little worried about exams...don't know now, would the concept map exercise [help]?... it's very difficult for me to say whether it would (Hemal, PH).

He 'cooperates' empathetically by reflecting on his own experience of pre-exam nerves and whether the concept mapping would have supported his goals as a student and the difficulty of this is clear.

I would argue that well-developed empathy is a prerequisite if a teacher is to develop authentic psychological safety. Data suggested that empathetic teachers work to understand what students feel unsafe about and why, how to make them feel safer and be willing to support them toward taking risks, despite fears. Cooperative interpersonal ER is a useful concept for critically reflecting on how teachers can build psychological safety that helps to better align teacher and learner goals and enables students to achieve these goals. Despite the emphasis on safety, ultimately students need to take risks and teachers can support this in a scaffolded way, as illustrated by Victoria:

"Well, you ask a question and then no one says anything and then you go, 'come on, someone be brave. You know, everybody else is feeling like you do'. They all think, always, I hold my hand up and I'm gonna make a fool of myself. So, they're still nothing. So then I carry on. And then I try again. And eventually within, you know, three weeks or so you build up a sense of...it's a safe space and they can ask questions and the minute one starts, then everybody else starts contributing" (Victoria, EEE).

Many teachers would give up before Victoria does, but she understands, as explored in Chapter 5, that her students' goal is to not appear foolish for getting a question wrong. She has a strong belief in her goal that interaction over questions will facilitate collaborative

learning, so she tolerates discomfort for several weeks, to better align hers and students' goals and behaviours.

When reporting on how teachers contributed to their emotion, some students demonstrated awareness of teachers' cooperative goals, recognising how teachers facilitated activities that enabled students to achieve their goals of feeling being more valued and independent in their learning. For example: "They are engaging and value our contributions, letting us figure out information for ourselves which helps with my learning" (Student200, MD).

"They allow us to share our answers to the problems, giving feedback to our responses before then explaining why the answer is the answer, which is very helpful" (Student236, MD).

I suggest that this demonstrates cooperative rather than paternalistic interpersonal ER because it allows space for students to feel discomfort before feeling the satisfaction of figuring out the answer.

One of the greatest surprises in this study to me and to teacher participants was students' empathy towards their teachers. Student data provided valuable insights into their perceptions and inferences of their teachers' emotions. Interestingly, these were very varied, and even contrasting, both in terms of emotion and attributions relating to perceived teacher goal achievement, for the same teacher, in the same Physics session: "[Teacher feels] Unimpressed with how little we discuss" (Student256, Physics).

"[Teacher feels] Accomplished since they were able to engage the students" (Student246, Physics).

This diversity of interpretation could again point to how constructions of our own and other's emotions are based on many factors, including individuals' expectations, goals and experiences. It also highlights the subjective and emotionally-influenced nature of evaluations of experience. Responses also demonstrated how students use social appraisals, based on emotion, both to infer what the teacher valued and teacher goals and to what extent they were helping the teacher to achieve that goal, as quotes in Table 8.3 below illustrate.

Illustrative student quote in response to survey question: How do you think your teacher(s) would say they feel whilst teaching this session/project?	Inferred teacher goals
“Good. They see their students putting their theoretical understanding in application” (Student19, EEE).	Goal related to applying theory
“That I should understand some things but also that it’s okay to test out the codes and see which works” (Student61, LS).	Goal related to learning by trial and error
“I think they would feel satisfied with the engagement...as there was a lot more answers from students” (Student268, PH).	Goal to increase class participation
“My teacher would find my group very cooperative and efficient in distributing different roles” (Student44, EEE). “Probably annoyed as they want everyone to be engaged and contributing” (Student23, EEE).	Goal relating to peer collaboration
“They are enjoying it a lot because students are working hard on difficult and interesting products” (Student157, ME)	Goal relating to creativity
“Some may feel a sense of pride from having seen us develop gradually” (Student275, PH).	Goal relating to long term development
“[Kris] feels great and enjoys giving us different types of stimulus and seeing how we react to them” (Student184, ME).	Goal to provoke a cognitive / emotional response.

Table 8.3: Student inferences of how teachers feel, linked to teaching goals

That students were able to identify and give an attribution for perceived or inferred teacher emotion suggests that teacher emotions may function as an important source of information for students, that enables them to construct meaning about educational goals and evaluate their learning behaviour and progress. These inferences may not always be accurate, where they were contradictory it is likely that some were not. Indeed, some teachers commented that they did not recognise some students’ inferred emotions. The data and this observation resonates with Immordino Yang’s (2016) assertion that:

“To learn, students empathically recognize the teacher’s actions, thoughts and goals, a process that reflects each student’s own social and cognitive experiences and preferences...students struggle to discern and reconstruct the teacher’s often time invisible mental actions in their own mind” (Immordino-Yang, 2016, p73).

The insight this study offers into how these processes function in STEMM university contexts, and barriers, demonstrates that we could be more transparent and explicit about our thoughts and goals. This could supplement the interpretation of emotion information and to help students overcome struggles to reconstruct teachers' "invisible mental action" that consume valuable cognitive resource and may not be possible for some.

In turn, students' social appraisals of teacher emotion, that inform their empathising, are valuable feedback for teachers. They provide an important source of evidence, both that students pay attention to, and care about, how their teachers feel in relation to the shared endeavour of learning. These are signals that are otherwise difficult to receive and read. Some student responses also suggested students sharing some responsibility for the success of a session, and included explanations for when they perceive teachers' goals had not been so well attained: "[Teachers feel] Potentially uncomfortable due to the lack of people willing to answer questions when they are thrown out into the crowd. But that's because the questions are difficult" (Student220, MD).

"[Teachers feel] Perhaps a bit down because we as a cohort are not very responsive to questions (due to it being a Friday afternoon)" (Student234, MD).

This emotion information can better enable teachers to evaluate attainment of their goals, including those relating to who is accountable for attainment (Frenzel et al., 2020). Furthermore, it offers evidence of authentic, embedded learner-teacher partnership (Bovill, 2020).

Several students also recognised that teachers may be making their own appraisals as to *why* students aren't enabling them to achieve their learning goals, as insightful Student233 illustrates: "They might feel that everyone is tired as very few people were answering the questions asked" (Student233, Medicine). I understood the use of the word *hopefully*, which appeared a number of times in student responses, as suggesting a strong sense of empathy, for example: "Hopefully proud of people working, but perhaps a little frustrated when people don't apply themselves to the task and instead spend time complaining to him!" (Student163, Mechanical Engineering). Furthermore, Student130 recognised their teacher's identity goal and the importance of alignment between teachers' and learners' goals:

"Alex is a great teacher. That is most importantly because [he] seems to teach because he wants to and does not have to. This may sound banal but I think the most important value in a teacher is the will to make their students understand" (Student130, LS).

I strongly believe that this, often invisible, source of emotion-related information can help to build rapport and foster student-teacher relationships.

Finally, students also demonstrated empathy for each other. In some cases, their responses illustrated peers being aware of each other's emotions, mentalising about why peers would feel this way *and* cooperative prosocial behaviours to help peers achieve their goal and support their wellbeing. Given that empathy is invisible and not always recognised by the intended target, it is interesting what students recognised as empathetic peer behaviour, as the following two responses to "How do your peers contribute to this feeling?" illustrate:

"By not rushing me through the task, by appreciating my input, by asking me questions" (Student109, LS).

"They are non-judgemental and helpful. I aim to reflect the same feeling" (Student112, LS).

Sometimes this empathy was reciprocally felt and this seemed to be motivated by recognition of similar ability and / or a keenness to contribute by supporting peers:

"All on the same level so we are helping each other. Made sure to be helpful to peers when I understood something" (Student63, LS).

"My student peers are exceptional since they help me with anything I don't understand. I also try my best to help others" (Student72, LS).

That the most well-developed examples of cooperative empathic motives and choices (presented above) were reported by Year 2 students suggests that these aspects of emotional competence may develop through emotion socialisation within university contexts.

8.8 Chapter conclusion

In this chapter, I have illustrated how, through the process of interacting in pursuit of their educational goals, teachers and students in STEMM university classrooms can come to perceive and understand each other's emotions and are motivated to offer prosocial support. Evidence presented suggests participants' ability to empathise was based on mentalising about how others may be feeling and why, as well as social appraisal that gave information about other's emotions, including those associated with their inferred goals. I suggest that, when it occurred, this empathic process was authentic and effective because, as socialising agents gain experience in their STEMM context, they learn to recognise each other's goals and associated emotions. This enhances empathy. Emotion information was received via varying channels, including observations, inferences and conversations, and challenges to receiving this information included unclear and disrupted signals, due to learning

environments and relationships not being conducive, or misinterpretation, including due to opaque or misaligned goals.

ER offered a lens for systematically analysing how both teachers and students act in empathetic and reciprocal ways to regulate emotions. Teachers described using a range of strategies, especially situation selection, situation modification and cognitive change to regulate students' and, to some extent, their own and colleagues' emotions. Students described deploying an impressive range of ER strategies, that were under-recognised by teachers, but could be valuably shared with other students to contribute to enhanced emotion socialisation. In this context, emotion socialisation involved students and teachers learning to recognise and regulate their own and each other's emotions in a way that is aligned with their goals, yet is sustainable.

I used data to challenge the widely held conception that empathising should have the goal of up-regulating positive emotion and down-regulating negative emotion. I argue that in STEMM high achievement contexts where students and teachers have complex and sometimes conflicting goals this broadening of how we understand and enact empathy is important. I have demonstrated that in STEMM education contexts teachers and learners can be 'emotional pragmatists' (Zaki, 2020) who recognise the educational value and motivational effects of uncomfortable emotion. However, due to the way counter-hedonic motives contradict common understandings of prosocial empathy, such approaches can create emotional and relational challenges.

By presenting this diverse, diverging and converging, range of emotional constructions and interactions, I have indicated that, just as there is no ideal emotion, there is also no one correct way to empathise. Instead, I offer a more nuanced perspective on empathy and how it supports development and wellbeing in STEMM academic achievement settings, including through balancing hedonic and counter-hedonic motives and goals. As illustrated, we must recognise that acting judiciously, deploying empathic concern, can be emotionally challenging for teachers and a risk they should not be expected to take alone.

9. Discussion and implications for emotion-informed STEMM curricula

9.1 Chapter introduction

Theoretically-underpinned by a social constructionist perspective on emotion (Lindquist and Barrett, 2008) and with empirical research guided by social constructionist and pragmatist paradigms, this study has sought to understand ways in which STEMM university students and teachers influence each other's emotional constructions. In Chapters Six, Seven and Eight, analysis of empirical data from focus group interviews with teachers and student questionnaires from seven disciplinary case studies were presented and discussed under three themes, judged to most meaningfully offer insight into how socialising agents in STEMM university classrooms socially construct emotion. The themes are:

Knowing: Transforming epistemic goals and relationships with knowledge

Evaluating: Social construction and appraisal of goal achievement

Empathising: Reciprocal emotion regulation for complex goal achievement

In line with reflexive thematic analysis, in this thesis' three Thematic Chapters, I adopted a qualitative reporting style, combining data with interpretations and drawing on existing literature to contextualise these themes and deepen my analysis of the data (Braun and Clarke, 2022). The purpose of this overarching 'Discussion and implications' Chapter is to draw together key ideas from data presented under each theme and highlight new understanding and insights that this study offers, in light of existing literature and theory. This will be used to identify implications for university teaching and learning practice and, specifically, suggestions for emotion-informed curricula.

The new insights developed through this study enables me to advance thinking in three areas, each of which will be elaborated below:

- Awareness of emotion in STEMM learning and teaching
- Emotional connection between student peers and teachers
- Use of emotion information in STEMM pedagogic practice

9.2 Awareness of emotion in STEMM learning and teaching

Participating teachers and students generally demonstrated impressive levels of awareness about their own and each other's emotions and how emotion influenced learning in science-based disciplines. This contradicts assumptions that STEM disciplines are emotionally detached (Kandiko-Howson and Kingsbury, 2024) and offers evidence for identifying those emotions that are specifically valuable for academic and professional STEM contexts (Sinatra et al., 2014). Far from emotion being separate to cognition, and specifically the endeavour of objective and rational thinking (Immordino-Yang and Damasio, 2007), participants' responses indicated an awareness that emotion is embedded in the process of STEMM education. Furthermore, data indicated participants' awareness and ability to articulate how emotion influences the cognitive processes involved in grappling with new knowledge, solving problems and making decisions.

Students in each cohort identified experiencing a wide range of varied and contrasting emotions, that suggested differing appraisals of the educational situation. In alignment with Pekrun's (2006) CVT, these appraisals were often based on individuals' appraisals of perceived value and control in relation to the educational activity and outcome. Student data indicated that many highly valued the interactions with peers, for both the academic and emotional support that it provided. Based on students' reported attributions for their own and other people's emotions, it was possible to infer their goals, and these included a combination of performance, mastery, social, relational, identity-related and ER goals. Students who indicated having mastery goals were more likely to report pleasant emotion (Dweck and Leggett, 1988) or to recognise that unpleasant emotional experiences could be valuable for learning. I suggest, based on the data, that those students and groups with more clearly articulated goals, a variety of complementary goals, and even an awareness of how goals influenced emotion, appeared better able to regulate their emotion in support of learning, including through collaboration.

Year 2 student responses were generally more fully developed in terms of expressing their own emotional attributions. They also demonstrated more willingness to articulate how socialising agents contributed to each other's emotions and how people in the learning setting were feeling, and attributions for this. This suggests that students develop these aspects of emotional competence as they progress through their degree programme and provides evidence of the process of emotion socialisation in HE. This concept has been applied to explain how learners in earlier educational settings develop the competency to recognise, understand and respond to emotion in contextually relevant ways through interacting with peers and teachers (Cekaite and Ekstrom, 2019, Valiente et al., 2020). It

has not previously been applied to university settings. A number of student respondents did not give responses to all questions, particularly those later questions that asked about how they thought others would be feeling and why. This was more common amongst Year 1 students and could be an indicator that students develop the contextual awareness that enables them to feel more confident to infer about others' emotions through their experience of university learning. This valuable emotional competence development may not be something that they are aware of. The demonstrable impact of emotional awareness on students' making meaning about challenging learning and of their emotional regulation capabilities, as evidenced by this study, indicates a valuable aspect of learning around which awareness and skills could be more deliberately developed.

The data overwhelmingly indicated that students who felt aware of peer emotion in relation to learning, as was often the case, and concluded that it was similar to their own emotion, reported feeling very reassured by this. This seemed to especially be the case where students reported experiencing uncomfortable emotions such as stress, nervousness or frustration and was sometimes explicitly linked by respondents to promoting wellbeing. Given the extent of positive emotion reported, I would argue that it is also valuable that students become aware of each other's positive emotion associated with learning, as this can transfer through social appraisal and counter socially constructed narratives of STEMM learning requiring the need to suffer (Jensen et al., 2023). Paying attention to positive emotion is also beneficial for wellbeing (Fredrickson, 1998). The degree of emotional awareness identified in this study surpasses the social and emotional learning that Brackett (2019) advocates, which focuses on individual students developing their ability to recognise, understand, label, appropriately express, and regulate their own emotion, rather than the interpersonal emotion skills that this study has revealed. Further, he highlights the relative challenge in integrating social and emotional learning into HE, owing to the cohort sizes and less close relationships between students and teachers (Brackett, 2019). Conversely, this study has illustrated that this social emotional learning may already be happening naturally through the process of STEMM learning and could be made more effective and widespread, based on suggestions within the findings.

In terms of teachers' awareness of their students' emotion and of the role of emotion in STEMM learning and teaching, this varied within and between teaching teams, but all participating teachers demonstrated taking student emotion seriously (Meyer, 2019). The perspectives and examples they shared did not reflect dominant discourses and stereotypes that emotions are irrelevant in rational, scientific-based education (Lönngren et al., 2024). Although interestingly, the focus group interview with mechanical engineering teachers did begin with one explaining "We're engineers, we don't really think about feelings" before

proceeding to talk about their influence on engineering education for 90 minutes. Teachers generally seemed unaware of the large variation in student emotion, and attributions for these, in the same specific context. This led some to talk in essentialised terms about the difficult and unhelpful emotions that student cohorts have, in ways that problematised these emotions. This is understandable as a way to cope with the complex and conflicting emotional information that is received from large UG cohorts (sizes ranged from 140 to 350 students per module cohort), that are diverse in many ways, including their goals and levels of emotional literacy. It may also be that teachers' goals form around resolving emotion that they perceive as impeding learning, so this is what attracts their attention. Teachers also did not seem to be aware of, or at least did not talk about, the important role of peers in providing emotional support to each other, including through their emotional awareness and competence, that was clearly evident in student data.

Taken together, these findings suggest that greater teacher awareness of the range of emotions, including positive learner emotion even in the light of academic difficulty, and contradictory emotional attributions, revealing the motivational value perceived in unpleasant emotion, would be valuable for overcoming assumptions. These include teachers assuming that students feel more negative about active and collaborative learning than they actually do (Andrews et al., 2020). Again, this could be achieved through gathering emotion data from students, which also prompted reflection on emotional experiences that appeared to have some valuable effects on sense of achievement and emotional wellbeing for students themselves and teachers considering the data.

This study did not seek to identify whether emotion in others had been correctly identified and was the same between people, as this aligns with a more essentialist view of emotions as universal, hardwired and something that happens to individuals in response to a situation or event in the educational environment (Evans, 2003). Rather, the study was interested in how socialising agents, individually and collectively, construct emotion and, in the process, make meaning of educational contexts, demands, goals and ways of navigating these. This included acknowledging that emotion in learning is subjective and dynamic, in a way that may not be 'accurately' categorised by others, but that gives a useful signal to socialising agents in the environment about people's needs and goals.

9.3 Emotional connection between student peers and teachers

I suggest that this study's most substantial contribution is to thinking about the emotional connections between student peers, and between students and teachers, and how deeper

understanding of these can inform learning, teaching and support for associated wellbeing. This builds on and offers alternative insight to the several quantitative studies that have demonstrated positive relationships between teachers' enthusiasm and students' enjoyment (Frenzel et al., 2019) and students' interest (Quinlan, 2019b). Instead, it demonstrates reciprocal connections between both teachers' and student peers' emotional experiences, through qualitative exploration. By using a social constructionist lens, this study goes beyond awareness of how individuals or cohorts feel about a specific learning context and identifies in what ways people reciprocally influence each other's emotions in learning contexts and what factors contribute to this. I have argued and illustrated that it is valuable to consider student and teacher emotion together, rather than separately as is more generally the approach (Postareff and Lindblom-Ylänne, 2011, Postareff et al., 2016).

The three themes each capture an important point of emotional connection between students and teachers. In Chapter Six, 'Knowing', is perhaps where the emotional connection was best aligned and least problematic. Students and teachers connected emotionally over their pursuit of STEMM knowledge and achievement of their knowledge-related goals. Student emotion was largely related to their evolving epistemic beliefs and goals and their ability to cope with the discomfort of not knowing, making mistakes and learning to work with uncertain knowledge. This was often mediated by their emotionally supportive relationships with each other, especially when they felt peers had similar emotions. Teachers' understanding of student emotion and their own emotional experiences were constructed in association with their experiences as learners in the discipline and teaching goals associated with helping students to develop understanding of, and ability to apply, disciplinary knowledge. This included supporting students to accept and work with new knowledge-related complexity and uncertainty. Teachers demonstrated differing relationships with knowledge and this influenced their emotional interactions with students and with colleagues, including during the focus group interviews. Broadly, teachers agreed that epistemic emotions were valuable for learning, although some found the discomfort that they created more difficult to support learners through than others. Student data did not associate epistemic emotions with unpleasant emotional experiences.

Emotion convergence (Parkinson, 2019) and emotional connection seemed to be most positive when students' and teachers' knowledge-related goals aligned, with transparency of the goal, understanding that the goal was challenging and a shift in goal orientation, from performance to learning/mastery, was perceived. A positive emotional connection was also identified when knowledge was considered to be relevant and valuable by both teachers and students. This is supported by neuroscientific evidence that relevance and perceived importance are key for activating and balancing networks of the brain that enable completion

of academic tasks and associated emotional regulation, and meaning-making (Immordino-Yang et al., 2019). This sense of personal relevance and emotional engagement also resonates with Immordino-Yang's (2016) assertion that "[e]ven in academic subjects that are traditionally considered unemotional, such as physics, engineering, or math, deep understanding depends on making emotional connections between concepts" (p19), and, I would also suggest, between people.

In Chapter Seven, 'Evaluating', the emotional connections between students and teachers were seen to be more problematic, with examples of diverging emotion or converging conflicting emotional orientations (Parkinson, 2019). This is likely because the objects on which emotion was focussed were student assessments and teacher evaluations, both of which often provoke negative emotion and even threat response (Jones et al., 2020). This seemed to be felt most strongly when objects were appraised as having high value and low controllability. Assessments and evaluations were seen as emotionally salient because they formed the significant basis on which students and teachers appraised their success in achieving their goals. Data suggested that a way to overcome negative emotion in the face of assessment and evaluation was to diversify ways of appraising progress towards, and success in achieving, goals. In this way, emotion was revealed as being a valuable source of information (van Kleef, 2009), with both teachers and students indicating that they consciously and unconsciously identified and made use of emotional signals and cues to monitor achievement of their academic, social and relational goals. This included engaging in social appraisal, using other's appraisals of the situation and information inferred about their associated emotion to inform their own appraisal, emotion and subsequent action (Manstead and Fischer, 2001). This can be a useful source of information, except when appraisals are inaccurate, particularly, as in this present study, when students' upward intimidating social comparisons (Burleson et al., 2005) were based on a lack of evidence. An important positive emotional connection identified between students was *normalising* social comparison that used evidence-informed strategies to support collaborative learning, including conversations about emotion.

In Chapter Eight, 'Empathising', data was presented to illustrate how student peers and teachers were emotionally connected through the ways that they regulated their own emotion during social interaction with others (intrinsic interpersonal ER), and regulated each other's emotion (extrinsic interpersonal ER), both in pursuit of their goals. Similar to Taxer and Gross' (2018) application to teachers in school settings, I suggest that university teachers' and students' ER attempts served both extrinsic and intrinsic regulatory functions. In contrast to Taxer and Gross' (2018) study, I would argue that although teachers and students sensed a contagiousness about the transfer of emotion in their classrooms, based

on my data and literature, I conclude that transfer of emotion information was via social appraisal and inference. In these intense STEMM academic settings, emotional influence is very powerful, owing to the strong salience and plentiful evidence of achievement. My findings contrasted with Volet et al.'s (2009) who found that when students were required to socially construct knowledge in challenging and less structured learning situations, even high achieving students demonstrated little propensity towards co-regulated learning with peers. In my study, in some cases, student descriptions of their emotional connections with peers even illustrated students considering their peers' goals, developing shared goals and, even reconsidering their own multiple goals, a process that involves significant social construction of emotion (Järvenoja et al., 2013). Given that my assertions are based on a sample of 280 volunteering students, some of whom may have been self-selecting based on their interest in emotion, I cannot generalise, however, my rich qualitative data does provide evidence of naturally occurring emotion socialisation and possibility for more. It may also be that the STEMM and/or active learning contexts contributed to this difference.

A key contribution from Chapter 8, 'Empathising', was based on application of Zaki's (2020) integration of empathy and ER to inform a critical perspective to data analysis. This provided strong support for an argument that I think it is helpful to make in light of the connection between emotion in learning and wellbeing. This is that an emotional connection based on a teacher up-regulating students' negative emotion or down-regulating their positive emotion, because it helps them to achieve important goals in the longer term, can be seen as a positive emotional connection. As 'emotional pragmatists' many teachers and students could recognise this, but powerful socially constructed narratives relating to student MHWB and 'student satisfaction' can make such counter-hedonic interpersonal ER goals and approaches seem risky for university teachers. New and critical perspectives on this emotional connection illustrated by the present study, provide a basis for taking a more nuanced view of the relationship between exposing students to difficult emotion in learning and supporting their wellbeing. This is further supported by evidence that "[p]eople who flexibly desire negative or positive states when they are useful, as opposed to merely desiring positive affect, exhibit greater psychological well-being" (Zaki, 2020, p522).

9.4 Use of emotion information in STEMM pedagogic practice

In Chapters Six, Seven and Eight, I presented data that demonstrated that students and teachers used emotion information, based on their own felt and others' inferred emotional experiences, to inform them of their success in achieving their goals, or otherwise. This included knowledge-related goals, broader academic goals, ER goals and relational goals.

In Chapter Eight, I illustrated how teachers used emotion information from previous and current students, as well as their own learning experiences to inform educational decision-making at all stages from selecting content to allocating groups, designing assessment and facilitating active learning sessions. Students' attributions for their emotions sometimes indicated how their emotion signalled to them that something in the educational environment was important and should be given attention. They also illustrated how they used information inferred from peer emotion to evaluate relative academic progress, as well as to guide empathic goals relating to supporting peers. Students also used teachers' inferred emotion to gain additional understanding of teachers' educational goals, to what extent they had been achieved and, in some cases, the roles students played and could play in this.

Unlike studies in which ER has been applied to school contexts (Taxer and Gross, 2018, Sutton, 2004), teachers in this study did not seem overly reliant on response modulation strategies to suppress their emotion. Rather they deployed a range of strategies to regulate students' and their own emotions that used emotion information, in a preventative way, to inform situation selection, situation modification and cognitive change. They did not explicitly refer to regulating students', nor their own, emotions but talked in lay terms about how they responded to student emotion information through all aspects of their teaching role. I suggest that the emotionally supportive practice identified in this study could be made more recognised, valued, systematic and widespread if teachers were made explicitly aware of ER strategies (Gross, 2015). This could be achieved by sharing illustrative examples, such as those gathered in this study and other sources, such as poems that convey the complexities of emotion in university teaching (Quinlan, 2019a).

9.4.1 Embedding STEMM-relevant emotion skills development

I suggest that there is value in the emotion information presented in this study being more systematically understood and used through the day-to-day processes of STEMM university learning and teaching. Teaching teams talked about deliberately embedding approaches to help students to recognise the role of emotion in their discipline's learning processes, including in ways that could develop emotional competence. There were three main reasons given for this: to empower students in their studies, to prepare students for professional life and to support student wellbeing, and often they were discussed as interlinking. Through discussion, being an emotionally competent student and graduate emerged as being important. There was a general sense that universities were not doing students any favours by protecting them from difficult emotion through paternalistic empathy (Zaki, 2020), thereby preventing emotion socialisation that prepared them for interacting emotionally in the 'real world', as Alex and Jessica raised:

“I do worry that these people are going to go into jobs and somebody is...going to be horrible to them. Because we've been so nice to them, when they've been horrible to us” (Alex, LS).

“5th and 6th years have felt quite at sea again because they've gone into this environment where they say, ‘Well, our consultants say to me, ‘Well just deal with it, what's the problem?’ That lack of empathy is quite strong, I feel” (Jessica, MD).

This is not to suggest that our students should be conditioned to perpetuate unhelpful social constructions related to emotion as distracting and how to ignore it, but rather to enable them to work with it. This can include helping students and teachers to make meaning of emotional interactions, rather than avoiding them. Jessica’s observations resonate with Boiler et al.’s (2018) findings that medical students felt they should not express emotion, but learnt to manage it through socialisation of emotion, including support from peers. However, neither, as Alex implies, should students be shielded from receiving important emotion information that may shape *their* pro-social behaviour. Shielding could occur due to teachers suppressing their felt emotion in response to socially constructed narratives around student satisfaction and fear of contributing to MHWB issues. As Hubert suggested, HE seems a logical stage at which to learn to deal with, even become habituated to, difficult emotions that are contextually relevant to STEMM academic studies and professions, in a way that could avoid future overwhelm and support wellbeing:

“So you stop being a student and become a professional, you will get frustrated and you will get hopeless... I guess if you don't experience this during your studies, you won't be able to deal with them...we all know that once you, once you start doing your own research, you get frustrated and hopeless at some point. I agree, I mean, you need all of them, so they don't overwhelm you later” (Hubert, CH).

I suggest that we should integrate and signpost the need to navigate the emotion experiences inherent in challenging STEMM learning into scientific and technical learning processes themselves. This present study demonstrates how this is not only possible, but also how it is already happening across STEMM disciplines. This builds on work to embed wellbeing in the curriculum (Houghton and Anderson, 2017) which I would argue is especially underdeveloped in STEMM disciplines for reasons set out in the Literature Review. Through this study, I am advocating an evidence-informed, STEMM-oriented approach, based on what STEMM teachers and students identify as contributing to important positively and negatively valenced emotions for both parties. I offer a more disciplinarily

integrated emphasis, guided by stakeholder perspectives on experience and educational impact of less comfortable emotion and a more nuanced awareness of the heterogeneity of empathy (Weigel, 2017), including teachers' and students' counter-hedonic goals. Recognising that empathy can be central to rising to STEMM challenges is important given existing stigma about emotionality in STEMM academia (Kellam et al., 2018) and concerns that "[e]mphasis on the emotions in higher education is irrelevant, a time wasting activity based on a generalised notion of personal vulnerability" (Ecclestone and Hayes, 2019, p97). Conversely, I argue that the appropriate emphasis on emotions can be empowering and academically beneficial.

If we are to better support this important, yet potentially fragile, emotion socialisation process, through which socialising agents in STEMM university contexts develop necessary emotional competence together, a key challenge is to get the balance right. This involves distinguishing between emotion that is unhelpful for learning, and can contribute to loss of wellbeing (Pekrun, 2019), and that which supports the higher purpose of HE to transform learners, including in terms of what they believe they can achieve and become. Victoria's quote highlights shifting UK HE sector thinking, and tensions this creates between balancing support for student wellbeing with concerns about upholding academic value and rigour:

"when I started in academia...it was more about, you know, this is the material, this is the assessment. Here it is. Get on with it. And now there seems to be a move towards actually being more aware and mindful of, you know, if we give the students 10 exams in three weeks at the end of the year that might cause them stress, anxiety, etc...That needs to be taken, taken into account but at the same time, I don't think it should get to the point where that's the main driver behind what we do" (Victoria, EEE).

In response to Victoria's justified and representative concern, I suggest a key issue is that, due to entrenched notions of academic standards and lack of nuanced understanding about emotion in learning, academic rigor and support for wellbeing can be unhelpfully socially constructed as incompatible. When actually, emotionally informed pedagogy can support high academic challenge.

9.4.2 Tried and tested approaches

Teachers referred to their tacit role in the emotion socialisation process, that I argue is embedded in these STEMM learning case studies, throughout interviews, as they reflected together on how they design challenging curricula and support students to navigate inevitable emotional experiences.

As illustrated in Chapters Six, Seven and Eight, a key emotion socialisation approach was 'normalising' emotion, and included acknowledging that a wide range of emotions are inherent in learning and in professional life, including teachers' daily experiences. Alex and Vivek both talked specifically about integrating this into their teaching and how normalising could helpfully be related to specific emotions that came up. Alex referred to a proactive approach in large group teaching and Vivek to a more responsive approach in small group tutorials:

"So I pre-empt that it's just gonna be hard for them at first, or just seeing error messages is going to cause panic, and you almost have to normalise those kind of feelings and normalise those behaviours" (Alex, LS).

"making it explicit, that it's okay to feel confused. Allowing students to be comfortable in their emotions, and to explain that this is a normal emotion, and that we as teachers sometimes feel these emotions, too. And I think it's more about what you then do with those emotions" (Vivek, MD).

Both teachers emphasised coming to see both the feeling, and response to it, as a normal part of the process. Ashford and Kreiner (2002) identify several strategies for normalising emotion, including reframing, that we have considered in-depth as an interpersonal ER. Another is habituation, a psychological process whereby an individual successfully adapts to an environment due to reduction of the cognitive shock of a negative emotional stimulus through repeated exposure, such as adjusting to the shock of receiving error messages, as Alex described. Habituation is supported by interaction with others, may be collectively experienced and can involve vicarious learning from others' experiences (Ashforth and Kreiner, 2002). Ashford and Kreiner (2002) caution that normalising can be used to maintain status quo, which is important to guard against. This highlights the need to acknowledge a risk of normalising and spreading unhelpful emotion and coping strategies, such as it being normal to feel overwhelmed and to overwork. Normalising tends to refer to reducing undesirable emotion (*ibid*), but in intense STEMM academic environments, I suggest it could be helpful to normalise emotions such as enjoyment.

Modelling, both experiencing emotions and how to work with them, was discussed in Chapter Six in relation to 'not knowing'. Teachers are well-placed owing to their connected emotional experience of working with challenging STEMM knowledge and disciplinary expectations regarding knowing. Molloy and Bearman (2019) recognise the difficulty for educators who attempt to navigate appearing both credible *and* vulnerable when modelling making mistakes, as highlighted in this present study. However, they advocate 'intellectual

candour', or expression of doubt and of thought processes, that they argue can build trust and promote transformative learning.

Modelling might also be in relation to navigating the connection between difficult emotion and staying mentally healthy. Teachers may also be on the receiving end of modelling so recognise how effective this process can feel. Simon talked about how helpful it was realising that apparently successful role models could also be coping models (Schunk et al., 1987):

“suddenly there were all of these high level professors and teaching fellows talking quite openly in the twittersphere about their mental health and the challenges they were facing. I was like, hang on, you know, I've been...suffering from imposter syndrome and so have all these other people who are hugely successful, and so this is obviously normal...we're all just trying to shift the balance to a healthy level of it... And I think maybe our students think that we don't feel these things. Do we ever let them be aware that we also go through the same kinds of emotions? So I think that's maybe something we could potentially do more of” (Simon, CH).

As a result, he talked about mentioning when he was feeling particularly tired or stressed in conversations with personal tutees. It is important to acknowledge here that not everyone will feel willing and able to model and contribute to emotion socialisation in the more explicit ways some research participants described. As MacFarlane (2004) reported, some academics are keen to maintain a clear delineation between ‘the academic’ and ‘the personal’. I would suggest that due to societal shifts in the acceptability of talking about emotion and the increasing prevalence of active, collaborative learning, where socialising agents are confronted by interacting emotions and need to respond, this may be changing. I do think MacFarlane’s (2004) questioning of “whether lecturers are sufficiently equipped to deal with the consequences of encouraging students to engage emotionally as well as intellectually” (p122) is still relevant and highlights the importance of teacher development in this area.

Finally, teachers talked about more structured and wider-reaching ways they could help students to use emotion information in their learning. This included using the Pekrun-based tool that I had modelled in the focus group interview to challenge beliefs about the effect of ‘negative’ emotions on learning, as the Chemistry teaching team illustrated:

Ina: “I think doing this exercise with a personal tutee would be excellent, wouldn't it?”

Hubert: “Yeah, because I think if they do this kind of exercise, they, you know, they don't really have to reveal what they feel which some might feel uncomfortable with. But at least they start thinking...”

Ina: “You could ask exactly the question that Kate's asking ‘how do you think students generally feel about this?’”

This included consideration of mitigating discomfort in students talking about their own emotions and has since been integrated.

9.4.3 Towards an integrated model

Based on this study, I make evidence-based recommendations for designing emotion-informed curricula and supporting learner and teacher engagement in emotionally responsive ways. Underpinned by more theoretically and empirically informed understanding of emotion in STEMM learning and teaching, this will enable pedagogic practice to be more deliberate and systematic, and less emotionally reactive. I suggest that emotional reactivity results from a lack of understanding about emotion in learning and teaching, and can lead to intrinsic interpersonal ER that positions all students as vulnerable and to paternalistic forms of empathy.

Accordingly, I have elaborated a model ([Figure 9.1](#) p225) to illustrate how the naturally occurring process of emotion socialisation, uncovered through this study, helps students and teachers to develop emotional skills to work with and influence constructions of emotion, specifically associated with active, collaborative learning in STEMM HE contexts. The socially constructed points of emotional connection between student peers and teachers are those experienced through practices of *Knowing*, *Evaluating* and *Empathising* (in orange on Figure 9.1). Through these emotionally connected experiences, students and teachers are continually developing the emotional competence that supports coping and goal achievement in STEMM academic contexts. Key aspects of emotional competence developed in this context are: *Being emotionally aware*, *Connecting emotionally* and *Using emotional information* (in yellow on Figure 9.1). As indicated by the double-headed arrow, the social psychological processes of *Social appraisal* and *Social comparison*, and neuroscientifically and psychologically informed *Social construction of STEMM education goals and emotions* influence the practices of *Knowing*, *Evaluating* and *Empathising*. Additionally, these three processes - *Social comparison*, *Social appraisal* and *Social construction* (in red on Figure 9.1), and the evidence of goal achievement they produce, contribute to on-going social appraisals, comparisons and constructions. The colours are significant; the red indicates socially influenced processes and the yellow signifies emotion

skills that give agency to individuals. These red and yellow factors combine to continually inform the orange points of emotional connection. Red is a stronger colour than orange or yellow and accordingly represents the powerful and pervasive influence of social forces on emotional experiences in university learning and teaching. Green is an optimistic and calming colour, representing the *Emotion socialisation* process that I see as so important for coping and succeeding in understandably challenging, but potentially threatening, academic environments. Ideally this gradually enables socialising agents, *Students* and *Teachers*, and the *Goals* they value, construct and pursue, to develop agency to challenge and change unhelpfully toxic cultures.

By being aware of, and understanding these connections and processes, and relationships between them, we can be more deliberate in our guiding and modelling toward emotional competence development. The goal of emotion-informed curricula is not about uniformity of emotional experience for learners or teachers. Rather, this framework is inclusive, allowing different people to have different emotions at different times. Furthermore, some individuals will be more able and willing to develop emotional competency than others. For example, those with alexithymia, who have dysfunctional emotional awareness (Hogeveen and Grafman, 2021) and some autistic people may find developing emotional awareness more difficult (Neff, 2024). The suggestion is not that emotional competency becomes yet another attribute to be measured, but rather it is valued because it enables individuals to support their own and others' learning collaboratively, including those who have less emotional awareness.

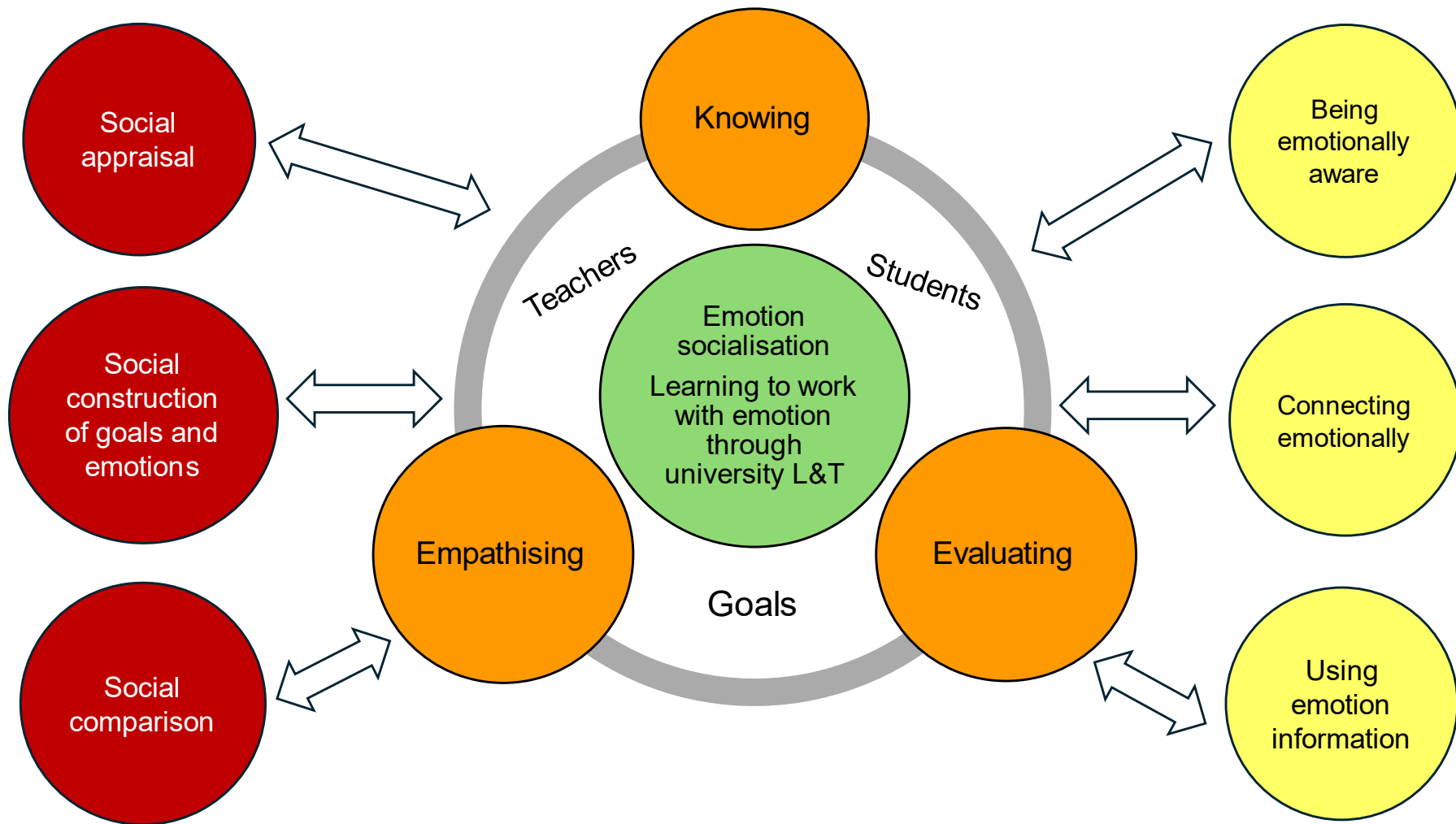


Figure 9.1: Model of social construction of emotion and points of emotional connection in STEMM learning and teaching

9.4.4 Practical suggestions for emotion-informed curricula and engagement

This section presents suggestions, based on theory-informed analysis of this study's data, for designing and facilitating curricula that are emotion-informed and emotion-responsive. As the present study demonstrates that it is helpful to look at student and teacher emotion together, rather than separately, suggestions take into account construction of emotion between all socialising agents. These are presented in Table 9.1 below.

Aspect of curriculum	Suggestions for developing emotion-informed STEMM curricula and engagement
Working with STEMM knowledge	• Raise awareness of the evidenced, and locally experienced, connection between knowledge, cognition and emotion, including the relevancy of emotion in academic and professional problem-solving and decision-making. • Talk with students about epistemic beliefs in your discipline and the stage of knowing (Baxter Magolda, 2010) being worked at: - 'absolute knowing': knowledge is seen as certain and the goal is to obtain correct knowledge. - 'transitional knowing': some knowledge is uncertain, teacher does not always know, learning involves exchanging perspectives. - 'independent knowing': accepting most knowledge is uncertain, sharing views with peers expands learners' abilities to think for themselves. - 'contextual knowing': being able to weigh up, judge, integrate and apply knowledge, within a specific context. • Broaden understanding of what 'knowing' in HE and beyond means, including appreciating different types of knowledge – factual, conceptual, procedural and metacognition (Krathwohl, 2010). • Acknowledge that productive engagement with knowledge can feel confusing, frustrating, stressful and uncomfortable and that this is felt through a desire to achieve knowledge-related goals. Challenge identity-goals related to being a knower, who has all the knowledge they need. • Define achievement emotions (Pekrun, 2006) and epistemic emotions (Vogl et al., 2019) and their value in STEMM learning and practice. • Challenge the classification of 'positive' and 'negative' emotions and explore the value of 'negative' activating emotion for learning (Ippolito et al., 2020).

	• Recognise the interconnected nature of learner and teacher emotion, in terms of enjoyment and enthusiasm of engaging with STEMM knowledge, as well as unpleasant emotions around uncertainty and not knowing. • Create time and 'safe' space to work towards goals where mistakes and failure is expected as part of the learning process. • Recognise and value emotionally informed pedagogic knowledge and communicate it with students and teachers through explanation of educational rationale.
Facilitating active, collaborative learning	• Be clear about the goals of the module/project (e.g. to learn to manage uncertainty) and include learning outcomes that develop and capture emotion competence and skills development. • Broaden achievement goals and rewards to include collaboration and align peer feedback processes with these goals. • Support students to identify the multiple goals amongst team members and to discuss how these may be current and future orientated, potentially complementary and conflicting. • Explicitly frame emotional experiences, such confusion when working with uncertainty, as relevant in STEMM study and professional practice. • Recognise the high level of emotional support that student peers can provide each other during collaborative learning and give time and space for emotional connection and trust to build. • Recognise that active, collaborative learning carries an additional cognitive and emotional load involved with understanding and cooperating towards other people's goals. Consider scaffolding cognitive load to allow capacity for emotional load.
Designing assessment	• Design assessments that feel worthwhile and personally significant, and acknowledge this may create stress as students want to rise to the challenge. • Acknowledge that interpersonal emotional influence is related to the object at which emotion is directed and individuals' orientations to that object (whether orientations converge or diverge). Use this to understand how students and teachers may construct diverging or conflicting, converging emotion (Parkinson, 2019) about the object of 'fair assessment' and be clear about how fairness in assessment is achieved • Reduce threat by being more transparent about the interacting roles and goals of tutor-assessors and acknowledge affective implications of this shift.

	• Give some control to students, such as responsibility for peer reviewing proposals and ability to challenge 'correct' answers, that can also facilitate increased understanding of what is valued. • Include substantial, higher-weighted assessments involving an output and/or social element that enable students and teachers to experience a collective sense of achievement, pride and enjoyment. • Consider the purpose of time pressure in light of educational goals and allow meaningful periods of time for students to dedicate their focus to pursuing their academic interests through project-work. • Identify how curiosity can be fostered and rewarded in assessment, through following interests, genuine experimentation (no-one knows the outcome) and depth over breadth.
Communicating about emotion	• Acknowledge and normalise the range of emotions experienced through active, collaborative learning and the valuable information they provide. • Pay attention to the various channels via which emotion information is transmitted and received and remove barriers that weaken and distort emotional signals, such as lack of in-person or audio-visual communication. • Discuss the relationship between emotion and goals in collaborative learning and use this to help students and tutors to understand why they feel the way they do. • Be transparent about learning and teaching goals (knowledge-related goals, mastery and performance orientation goals, identity goals, interpersonal ER goals) to facilitate fuller cooperative interpersonal ER between teachers and students. • Suggest students identify and keep a balance between academic, professional, social, relational, short-term and longer-term goals, to help maintain healthy perspective. • Students and teachers use social appraisals to make inferences about each other's goals and associated emotions. Encourage students to supplement their social-appraisal-based inferences with talking with peers about how they feel about learning and why.
Evaluating learning and teaching	• Encourage teachers to gather a variety of emotion information at useful times to support more accurate inferences and avoid assumptions. For example, ask:

	○ How is this session / module / project making you feel? ○ Why do you think you feel this way? ○ How do peers / teachers / you contribute to this feeling? • Recognise that giving and receiving emotion information contributes to ongoing emotional competence development for students and teachers. • Pay attention to the various emotions experienced by teachers when receiving and interpreting teaching evaluations, talk about this with colleagues and triangulate with other sources of data. • Make meaning of emotion information, as subjective, context-dependent data, not objective fact, using the concepts presented in this study. • Model how you manage emotions linked to receiving feedback with colleagues and students. • Encourage evidence-informed social comparison and normalising social comparison by talking about learning challenges and strategies with collaborative coping models.
Learning to regulate emotion	• Identify areas of emotional challenge in the curriculum and, if it is important for developing emotional competence and resilience, support this, rather than designing it out. • Scaffold self-reflection on the emotional impact of learning and growing emotional competence over time, for example, using RULER (Brackett, 2019). • Acknowledge that students may already be aware of their own and others' emotions in learning and illustrate how they are likely to regulate these in pursuit of goal achievement. • STEMM teachers described using a range of interpersonal ER strategies but did not demonstrate deliberate choice nor awareness of how these interconnected. Teachers could develop better understanding of interpersonal ER strategies, use a fuller range at each stage of their teaching practice and discuss with colleagues. Use tools based on Gross' (2015) ER model and illustrative examples to identify appropriate strategies – situation selection, situation modification, attentional deployment, cognitive change or response modulation.

	• Use cognitive change strategies to normalise the experiencing of a variety of emotions and model how you work with them. • Experienced and reflective teachers use a combination of intrinsic and extrinsic interpersonal ER, and hedonic and counter-hedonic goals. Teachers should aim to maintain boundaries by practicing cognitive empathic concern, rather than emotional experience sharing that can more easily lead to intrinsic interpersonal ER. Explain rationale for chosen interpersonal ER to students, where appropriate. • Students are and can be 'emotional pragmatists' (Zaki, 2020) who set counter-hedonic goals for themselves. Facilitate discussion between peers and tutors about the educational value of a variety of goals and the role of counter-hedonic goals. • Students demonstrate motivation and ability to perceive, understand and offer prosocial support to peers. This can be encouraged at the beginning and during group work. • Recognise the process of emotional socialisation and set emotion-related learning goals/outcomes that value and strengthen it. Be aware of the negative effects of interpersonal emotional influence, such as normalising feeling continually stressed and overwhelmed, leading to maladaptive approaches, including over work. • Structure teaching to enable student-teacher and peer relationships and trust to build. This can facilitate emotional interaction, including developing reciprocal empathy, based on supporting each other to achieve goals. • Support teachers to talk about how they deploy extrinsic and intrinsic, and hedonic and counter-hedonic interpersonal ER, which may focus on achievement and wellbeing over the longer term, and the emotional impact of this on teachers.
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Table 9.1: Suggestions for developing emotion-informed STEMM curricula and engagement

10. Conclusion

10.1 Revisiting research questions

To conclude this thesis, I have explicitly mapped the findings and implications discussed in detail in preceding chapters against the research questions.

RQ1. What emotional experiences do students and teachers in STEMM university learning and teaching socially construct and what attributions do they make for these?

This study has demonstrated that despite stereotypes to the contrary (Lönngren et al. 2023, Immordino-Yang, 2016), participating STEMM students and teachers were readily able to recognise experiencing a wide range of varied and contrasting emotion and to identify diverse attributions in relation to their interactions and meaning-making. Some of the most notable emotional experiences were those associated with their pursuit of knowledge related-goals. This study's findings emphasise that the strength of connection between emotion and knowledge in a research-intensive, STEMM context cannot be underestimated. For students, this sometimes meant undergoing the, often uncomfortable, process of evolving epistemic beliefs about the nature of knowledge and what it meant to be a knower and knowledgeable. Attributions for why students felt the way they did included relationships with knowledge and each other as knowers. For example, those whose responses implied a transition to conceiving knowledge as less certain and who recognised the constructive potential of cognitively interacting with peers, appeared to experience less emotional discomfort, or at least recognised its motivating influence on learning (Ippolito and Kingsbury, 2024). Teachers' emotions were associated with their beliefs about the purpose of university education in their discipline, linked to their experience as learners and their own relationship with disciplinary and pedagogic knowledge. Construction of teacher emotion was influenced by their varied teaching goals and the extent to which they perceived that they were able to achieve these.

Being assessed as learners and being evaluated as teachers was a second notable point of emotional connection that led to construction of strong emotion between socialising agents. This prompted discomfort and, in more extreme cases, a threat response, especially when students or teachers appraised the value of the assessment/evaluation as being high and control or perceived competence as being low. Conversely where assessment allowed time and space to consolidate and apply understanding, supported meaningful cooperation between peers with compatible goals, enabled the development of self-efficacy beliefs and a shared and recognised sense of achievement these resulted in more positive educational

experiences for students and teachers. Teachers felt most positive about evaluation when it enabled them to understand the impact of their teaching efforts and to evaluate achievement of their chosen teaching goals.

RQ2. What are the reciprocal emotional interactions between student peers and teachers and what factors influence this process?

Participating students and teachers demonstrated higher than expected awareness about each other's emotions, attributions for these and how socialising agents influenced each other emotionally. The data illustrated how student peers, students and teachers, and even teacher colleagues, influenced each other emotionally in many ways and pursuit of individual and shared academic goals was a significant contributing factor of these reciprocal processes. The three most significant points of emotional connection between them related to the STEMM context relevant processes of Knowing, Evaluating and Empathising, as detailed in the Discussion and Implications Chapter and illustrated in Figure 9.1. Participants described deploying a range of intrinsic and extrinsic interpersonal ER strategies in support of their own and each other's learning and teaching goal achievement, and wellbeing. They demonstrated varying empathic motives, that included hedonic and counter-hedonic goals and approaches. This provided valuable illustrations of nuanced and under-recognised understanding about the complex relationship between emotion in learning and university student wellbeing. It raised the importance of recognising the emotional impact on teachers with counter-hedonic goals which, despite being valuable in challenging STEMM achievement contexts, mean teachers may be criticised for being non-empathetic. As discussed in Chapters Six, Seven and Eight, factors influencing reciprocal emotional interaction were awareness of each other's emotions and attributions, quality of relationships between socialising agents, awareness and alignment of socially constructed educational goals, outcomes of social comparison between peers and the use of emotion information, including through social appraisal of emotion and achievement of goals.

RQ3. What are the implications, and how can awareness about emotional interaction in STEMM education contexts inform educational design and pedagogy that supports achievement and wellbeing?

Based on careful consideration and integration of existing literature and theories, alongside analysis of empirical data from my seven STEMM case studies, I have elaborated a model (see Figure 9.1) to support understanding of the nature of reciprocal emotional interaction in STEMM university learning and teaching and the factors that contribute to, and result from, emotional constructions. I have also derived a collection of suggestions for designing and facilitating emotion-informed and emotion-responsive STEMM curricula that avoid unhelpful

emotion-reactive approaches to addressing learning and assessment-associated student wellbeing issues. I propose that these evidence-informed recommendations should be used to guide more emotionally informed curriculum design and facilitation that is inclusive of all individuals and their diverse range of emotion and emotional attributions. It provides advice and educational and psychological rationale for paying attention to emotion that is important for learning and teaching, and minimises unhelpful emotion that creates unnecessary cognitive and emotional load and has negative influence on sense of wellbeing. The suggestions include developing students' and teachers' pedagogical and emotional competence in a way that is integrated into the learning and teaching of STEMM disciplinary knowledge, at a point where emotional awareness, emotional connection and emotion information is relevant. This, in turn, will support more educationally and psychologically helpful social construction of emotions, meaning and goals in relation to STEMM university learning and teaching.

10.2 Original contributions

This research study makes several theoretical and methodological contributions to the fields of STEMM HE, university learning and teaching more widely, and the research of emotion, in the context of HE.

10.2.1 Theoretical contributions

The first theoretical contribution this study makes is to develop a contextually relevant theoretical framework for understanding socially constructed emotion in university learning and teaching (See [Figure 3.3](#) p60). This connects well-established and current understanding about the nature of emotion from psychology, neuroscience and education-based perspectives. It foregrounds conceptualisations of emotion as goal-based and socially constructed, which are so relevant to collaborative learning in achievement-focussed university contexts. This theoretical framework is valuable, as many existing studies that consider affective dimensions of university experiences, particularly in STEMM contexts, are criticised for being under theorised. I suggest that this may be both because emotion is such an obvious and everyday experience that it does not warrant theoretical consideration and, conversely, because emotion is such a complex concept, with many disciplines contributing to its understanding, that it is difficult to access. The risk is that unhelpful assumptions, including regarding unsubstantiated connections between emotion in learning and MHWB, can be made if the function of emotion in university learning and teaching is not well-understood. I hope that by including influential frameworks, such as interpersonal ER

(Gross, 2015, Zaki, 2020) in this framing, I can contribute through their empirical application to new contexts; first, to a science-based university learning context and second, to consider interpersonal ER between university students and teachers.

The second theoretical contribution is to consider the collective, socially constructed nature of emotional experience in HE contexts. Given the prominence of emotion as an individual experience, including negative emotion being seen as the individual's problem, the interconnectedness of emotion is often not considered. A more shared and socially constructed perspective is valuable for informing curriculum design that, rather than ignoring the omnipotent influence of students' and teachers' emotions, or seeing them as something to be solved or made uniform, sees them as integral to the cognitive and social processes of learning itself and a valuable source of information about goal achievement and associated wellbeing. This is also valuable for informing university MHWB strategies, especially in relation to the Learn domain (Universities UK, 2023), so that they avoid pathologising normal emotions felt and actively constructed in the process of learning and teaching. This includes emotions that feel unpleasant or negative, in a neurophysiological and psychological sense, yet are important for learning, and for psychological and brain development (Immordino-Yang et al., 2019).

The final theoretical contribution is to elaborate emotion socialisation in the context of university education, as the process by which socialising agents, students and teachers, continually develop their own and each other's emotional competency through the process of interacting emotionally in purposefully challenging educational settings. This is important not only at this life stage, but also for confronting with new situations and learning to balance often competing demands of personal individuation and individual goal achievement, with social integration and shared goals (Hurrelmann and Bauer, 2018), including interpersonal ER goals. Rather than seeing emotional competence as another thing to be achieved, I suggest that context-relevant emotional competence development is an ongoing project, integrated into the process of disciplinary teaching and learning. It involves learning to address new emotional challenges, in new and changing academic and professional contexts as they arise. This helps to address criticisms that paying attention to emotion is not the role of HE teachers, or that it positions students as vulnerable. Rather it gives both individual and collective agency for coping with, and constructing perceptions of success in, university learning. This has been elaborated as a 'Model of social construction of emotion and points of emotional connection in STEMM learning and teaching' (See [Figure 9.1](#) p225). Looking at inclusive practice and sense of belonging through the theoretical lens of socially constructed emotion is helpful for practitioners and policy makers. It can support more

nuanced understanding regarding individuals' complex meaning making about how they feel and why.

10.2.2 Methodological contributions

This study's first methodological contribution is to take a qualitative approach to considering how STEMM university student peers' and teachers' emotions interact and influence each reciprocally in the process of learning and teaching. I know of no other studies that do this. Existing research into reciprocal interpersonal emotional influence in educational settings has been largely quantitative and primarily school-based. When seeking to inform development of curricula and pedagogy, this form of triangulation that critically considers and contrasts different stakeholder perspectives is important for increasing validity, and this was particularly the case due to the iterative approach taken to data gathering and analysis. A fuller picture of the educational experiences and perspectives is especially important for phenomenon as dynamic, subjective and socially influenced as emotion. The desire to include a larger group of students, with a wider range of perspectives, than could have been achieved through focus groups or interviews, guided the use of in-situ student questionnaires. This gleaned 280 valuable sources of data and its usage in this study contributes to the methodological discussion that fully qualitative surveys are underutilised yet can provide a rich qualitative data (Braun and Clarke, 2021).

The second methodological contribution is the way this study models alignment of the theoretical conceptualisation of emotion as socially constructed with the methodological approach that sought to capture the process and outcomes of this social construction. Through the data gathering and analysis process, social construction of emotion happened on a number of levels. First, in focus group interviews with teachers, as data demonstrated, conversations resulted in socially constructed meaning making about the purpose and influence of learner and teacher emotion. Second, in response to the data collection questions, individual students articulated their understanding of how people in their STEMM learning and teaching contexts feel, why, and how they influence each other's emotions, constructing social meaning as they did so. Third, in follow-up interviews with teachers from five case studies, our conversations about student questionnaire data supported another layer of social construction, where both teacher and student perceptions of the relationship between emotional interactions, learning and teaching were considered alongside. Finally, through my data analysis, I added a layer of social construction by making meaning and connections between emotion data from socialising agents in each case study, that had not been articulated by research participants, but was possible in light of theory and my experience. Furthermore, by integrating data across all seven case studies, I have developed a socially constructed interpretation of how emotional interactions might be

characterised in STEMM disciplines. This also responds to calls from the field of emotion in HE for research that considers socio-cultural factors (Pekrun, 2019).

10.3 Limitations

Limitations of this present study include that it is based on a single site study, in a UK research-intensive, STEMM-focussed institution, so it is possible that the findings are specific to this context. I have sought to increase the applicability by sampling from multiple STEMM disciplines and teaching contexts, and giving detailed insight to enable value of ideas to be judged and applied in other contexts. This includes the elaboration of a theoretical framework to guide understanding and research of emotion in university learning and teaching ([Figure 3.3](#) p60), a model for illustrating the process of social construction of emotion in university learning and teaching ([Figure 9.1](#) p225) and a list of suggestions for developing emotion-informed curricula ([Table 9.1](#) p226-230).

Second, as I purposively selected the modules, on the basis of reputational case sampling, as examples of interesting active and collaborative learning, designed and taught by teachers whose context and practice I was aware of, this may have introduced selection bias. It may mean that the views and practices of the STEMM teacher participants are not representative or reflective of those in wider STEMM education communities. It is important to note, however, given the focus on emotion in collaborative STEMM learning, that there was no prior awareness of teachers' nor students' levels of emotional competence (Ippolito and Kingsbury, 2024).

Finally, I intentionally did not collect demographic data, so am not able to say anything about the ways in which aspects of an individual's identity, such as gender, age, race, ethnicity, linguistic background or socio-economic status, contribute to social constructions of emotion. Extensive literature on the experiences of under-represented and minoritised university students and teachers suggests this may be the case (Meadhbh Murray et al., 2023). It was a deliberate decision not to consider emotional experience through an equity lens. I did not want to distract the focus away from diversity of emotion or risk my interpretations of data being guided by bias or assumptions based on the many stereotypes in relation to emotionality and an individual's identity. I was also concerned that collection of additional demographic data would be off-putting to students, and that, given my preference would be to take an intersectional approach, it was unlikely that there would be enough participants from any group to draw any meaningful conclusions about the relationships between individual identity and constructions of emotion.

10.4 Recommendations and future research

10.4.1 Improving educational practice

On the basis of this study, I have presented substantial, evidence-based suggestions for the development of emotion-informed and emotion-responsive curricula and engagement of students and teachers (see [Table 9.1](#) p226-230). My vision is that these suggestions should complement and reinforce existing approaches to inclusive teaching and learning practice, rather than be an additional and potentially distracting element for busy teachers to consider. It would be ironic if this contributed to unhelpful emotional discomfort! Rather, I believe this lens can substantially shift perceptions regarding the connections between students' and teachers' emotional experiences in a way that may counter narratives that currently create division and hamper positive relationships, and foster more positive emotional interactions. Such suggestions and illustrative examples could be integrated into workshops to inform reflection and discussion between university teachers. I have already begun to do this at my own university, including through workshops, integration into the Master's in University Learning and Teaching and personal tutor training, and the establishment of a Special Interest Group on Emotion in STEMM Education. In addition, I have delivered workshops at other universities and at international conferences, published papers, developed online workshops and resources and contributed as a member to the international Emotions in Engineering Education Network. These contributions have been well-received and have enabled me to interrogate and refine my ideas and approaches.

10.4.2 Informing policy-making

In terms of policy, as discussed, these findings can valuably inform university MHWB strategies, to encourage them to pay equal attention to the aspect of university life that relates to learning. They should also avoid medicalising the normal range of varied emotions experienced by university students in the pursuit of their educational goals. The more nuanced way of considering empathy in HE contexts that this study demonstrates and advocates, including awareness of positive influences of counter-hedonic interpersonal ER motives, will be useful for supporting teachers and educational leaders challenged by balancing concerns about MH with creating challenging and meaningful learning opportunities. More specifically, this understanding could inform mitigating circumstances policy and process that can result in students, sometimes unwittingly, relabelling difficult emotion as a mental disorder (Armstrong and Byrom, 2023). Finally, suggestions can be applied to programme approval and quality assurance review processes to ensure that new and modified degree programmes pay attention to aspects that lead to helpful and unhelpful

emotional constructions, such as collaborative learning design, assessment types and timings, teacher evaluations and perceptions of success.

10.4.3 Future research

Future research could use the proposed theoretical framework to consider the influence of dimensions such as culture, race, gender or neurodivergence on emotional experiences and interpersonal emotional influence in STEMM HE, in different disciplines or across disciplines. Longitudinal studies, that involve the application of suggestions for developing emotion-informed curricula and practice, could be conducted to consider the impact on social constructions of emotion and relationships between student peers and teachers. This seems particularly important given the positive impact that relationships have on experienced emotion and wellbeing, and concerns about current barriers to relationship building (Tormey, 2021).

10.5 Personal reflections

This study has involved a journey that has seen me grapple with literature, theories and research approaches from several disciplines in an attempt to present a theoretically robust approach to considering the nature and function of emotion in university learning and teaching. This has created opportunity for exposure, and contribution, to a psychology community through the Emotion 2023 conference, engagement in various mental health research conferences, and contributions at university learning and teaching and higher education-focussed events. All of these have contributed to my understanding and emotional constructions, especially depending on how I appraised them in terms of their influence on my sense control and competency, and their value for enabling me to achieve my many interacting personal, professional and study-related goals. I have enjoyed moving between different students' and teachers' perspectives, trying to piece together and reflect some of the many complex emotional constructions that they create through their interactions. Given my passion for educational development, it has been rewarding to think deeply about the omnipresent phenomenon of emotion and really consider its educational purpose and implications. In my own teaching and educational leadership practice, I have been using my enhanced understanding to guide challenging decision-making that inevitably involves individuals' differing orientations, goals and emotions. I am learning to find an educationally productive balance between safety and discomfort (Walker and Palacios, 2016). Finally, it has given me confidence to speak up and reflect the under-represented

voices of university teachers in research and policy-making circles, particularly in relation to the role of universities and university teachers in supporting student wellbeing.

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Appendix

Appendix A: Approved ethics application

Imperial College Education Ethics Research Process (EERP) Application Form

Section A - Investigator(s)

Principal Investigator

Please name the person performing the research here. If the application is for a student project, please name the supervisor below and add details of all other co-investigators or collaborators as appropriate

1. Name:	Kate Ippolito
2. Email: Imperial College not private	k.ippolito@imperial.ac.uk
3. Title of study:	Reciprocal emotional attribution in the active learning classroom.
4. Summary of skills, experience relevant to the study and in any procedures to be used. (50 words max)	I am an educational developer with 20 years insight into how individuals describe their emotions in relation to learning and teaching. I have a MA in Higher and Professional Education. My work has involved researching and publishing on the impact of pedagogical approaches including active learning such as TBL, assessment and feedback methods, role modelling and intercultural learning, all of which have an emotional dimension.
5. Is this a student project?	☒ YES ☐ NO if 'YES' you <u>must</u> complete 6-9 below
6. Supervisor Name;	Prof Martyn Kingsbury
7. Supervisor Email: Imperial College not private	m.kingsbury@imperial.ac.uk
8. Course of study:	PhD in Education
9. Please confirm the supervisor has read and agreed to this application?	☒ YES ☐ NO EERP may verify this with your supervisor

Co-investigators

If there are more than 3 co-investigators, please use a separate sheet and follow the format below

10. Name:	
11. Position:	
12. Email: Professional / College not private	

13. Name:	
14. Position:	
15. Email: Professional / College not private	

16. Name:	
17. Position:	
18. Email: Professional / College not private	

Section B – Project Summary

Project summary ...

Please provide brief details about your proposed project using simple **LAY** terms:

19. What is your Main Research Question?	What is the dynamic between student and university teacher emotion in the active learning classroom and what factors influence it?
20. Rationale Please <u>briefly</u> describe the reason for the study. What do you hope to find? Why may this be important?	In recent years student mental well-being has become a source of growing concern for UK universities (Neves and Hillman, 2019), as well as in wider Europe and the US (Van der Heijde, Vonk & Meijman, 2015; Barra Stolzenberg, 2018). UK HE is being strongly encouraged to make student mental well-being a strategic priority, with success being judged against the new University Mental Health Charter (Student Minds, 2019). This policy-level activity is accompanied by recommended pedagogical responses such as embedding mental well-being in university curricula (Houghton & Anderson, 2017). However, there is disagreement over the academic's responsibility and role in this (Ecclestone & Hayes, 2019) and some suggest that universities are at risk of over-medicalising the normal emotional responses of young adults as they respond to the challenges of academic transitions (Turner, 2018). The challenge faced is acknowledged as being complex and multi-layered, including the need to better understand what is meant by student well-being (UUK, 2017). It is consistently reported and recognised that academic pressures, including assessment, are most anxiety-provoking and challenging to well-being (El Ansari et al., 2011, Mentality, 2015). Given it would be impossible and unhelpful to remove all stressors, potentially university can provide environments where students learn to cope with normal stressors, and the emotions, such as anxiety, that they give rise to. A challenge and an opportunity in this regard is the active learning environment where emotions are more evident and often contradictory (Charalambous, Hodge & Ippolito, in press). Given sector-wide desire to build an evidence-base for informing the development of active learning approaches and Imperial's need to equip students and teaching staff to thrive in active learning settings (Imperial, 2017) this seems an important focus. I believe that a fruitful avenue for addressing mental well-being is to better understand how students and teaching staff recognise, make sense of, attribute and regulate emotion in active learning settings, including in response to perceived stressors. There is a small but growing body of research exploring emotions in learning (Pekrun, 2019), that I hope to contribute to, but little on the reciprocal dynamic between teaching staff and students. Exploring this interplay between agents may offer insights for improving emotional awareness and attribution and promoting agency for emotional regulation in learning,

	including acknowledgement of the emotional disorientation (Quinlan, 2016) involved in successful and transformative learning. Departing from the language of “support” and “management” of emotions in learner wellbeing, this study seeks to explore teaching staff and students’ perspectives and experiences, in order to reframe existing ideas about emotion in university learning and teaching and what can be influenced by whom. Further, it aims to identify practical approaches to increasing emotional awareness in our practice and institutional culture. This more sustainability-focussed view of emotions for learning recognises the need to prepare our graduates for uncertain futures (Barnett, 2004), and the variety of emotions that are likely to be evoked by this uncertainty. Drawing on research from neuroscience (Barrett, 2017), psychology (Cavanagh, 2016; Pekrun & Linnenbrink-Garcia, 2014), and education (Mezirow, 1991), this study’s key areas of focus will include re-examining and conceptualising the role of positive and negative, activating and deactivating emotions in learning. In doing so I hope to challenge university teachers’ and students existing beliefs about emotion in learning, offer an alternative, more agentic perspective for supporting well-being in university curricula and offer different approaches for navigating this with key stakeholders. Barra Stolzenberg, E. (2018) The Mental and Physical Well-Being of Incoming Freshmen: Three Decades of Research. Available at: https://www.higheredtoday.org/2018/09/06/mental-physical-well-incoming-freshmen-three-decades-research/ Barnett, R. (2004) Learning for an unknown future. <i>Higher Education Research and Development</i> 23(3), 247-260. Barrett, L. F. (2017) How emotions are made: the secret life of the brain. Cavanagh, S. R. (2016) The spark of learning: energising the college classroom with the science of emotion. Morgantown: West Virginia University Press. Ecclestone, K. & Hayes, D. (2019) The dangerous rise of therapeutic education. London: Routledge. 2nd edition. El Ansari, W. Stock, C., Snelgrove, S. Hu, X. et al (2011) Feeling healthy? A survey of the physical and psychological well-being of students from seven universities in the UK’. <i>International Journal of Environmental Research and Public Helth</i> 8, 5, 1308-1323 Houghton, A-M. & Anderson, J. (2017) Embedding mental wellbeing in the curriculum: maximising success in higher education Available at: https://www.heacademy.ac.uk/knowledge-hub/embedding-mental-wellbeing-curriculum-maximising-success-higher-education Mentality (2015) Mentality Campaign Survey Report Available at https://www.imperialcollegeunion.org/news/stress-and-mental-health-imperial Mezirow, J. (1991). <i>Transformative Dimensions of Adult Learning</i>. San Francisco, CA: Jossey-Bass. Neves, J. & Hillman, N. (2019) Student Academic Experience Survey 2018 Available at https://www.hepi.ac.uk/2019/06/13/student-academic-experience-survey-2019/ Pekrun, R (2019) Inquiry on emotions in higher education: progress and open problems, <i>Studies in Higher Education</i>, 44:10, 1806-1811, DOI: 10.1080/03075079.2019.1665335 Pekrun, R & L Linnenbrink-Garcia, L. (Eds.) (2014) <i>International Handbook of Emotions in Education</i>. New York: Routledge Quinlan, K.(2016). How Emotion Matters in Four Key Relationships in Teaching and Learning in Higher Education. <i>College Teaching</i>. 64. 1-11.10.1080/87567555.2015.1088818.
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	Student Minds (2019) The University Mental Health Charter Available at https://www.studentminds.org.uk/charter.html Turner, C (2018) Universities may be fuelling the mental health crisis, leading psychiatrist warns Telegraph 29 June 2018. Available at: https://www.telegraph.co.uk/education/2018/06/27/universities-urged-invest-mental-health-services-minister-launches/ UUK (2017) #step change Mental Health in Higher Education https://www.universitiesuk.ac.uk/stepchange Van der Heijde, C.M., Vonk, P. & Meijman, F.J. (2015) Self-regulation for the promotion of student health. Traffic lights: the development of a tailored webbased instrument providing immediate personalized feedback, Health Psychology and Behavioral Medicine, 3:1, 169-189, DOI: 10.1080/21642850.2015.1049950	
21. Proposed dates	Start Date April 2020 From the start of advertising / recruitment	End Date April 2025 To the end of data collection / analysis
22. Methods: Please check the box of any/all of the list of methods that you intend to use. If you are intending to use methods that are not in the list please provide <u>brief</u> details in the space to the right.	☒ Questionnaires ☒ Observation (including ethnographic research) ☒ Interviews ☒ Secondary analysis of pre-existing data ☒ Focus Groups ☐ Other (please give details below)	
23. Location(s): Where will you do your research?	Imperial College premises. Observations will occur in their natural settings. Interviews and focus groups will be held in either a staff member's office or a private meeting room, or given current COVID-19 restrictions, via Skype or Teams. In some cases, staff will be asked to choose the room they most or least like teaching in and interviews will be conducted there. In this case, every effort will be made to ensure that the location remains private and the interview uninterrupted. Student focus groups will be conducted in departmental teaching rooms, ensuring that locations are safe, mutually convenient and allow for appropriate privacy and the recording of data.	
24. Participants: Please clearly state what sort of people you plan to recruit into the project, and describe any inclusion/exclusion criteria	Imperial College staff involved in teaching and supporting learning, including those on academic contracts, teaching support contracts and research staff who engage in teaching and supervision activities, across all grades and levels of seniority. Imperial College UG and PG students. Given the research question, a more purposeful sampling approach will be taken that seeks to get depth and focus rather than representativeness.	

25. Recruitment: Please clearly state how your study population (defined above) will be recruited.	Staff participants will be recruited through three mechanisms: 1. Directly 2. Via email, inviting participants 3. Following discussion at relevant meetings (e.g. CHERSNet, EDU information sessions, education committees). Student participants will be recruited via a single invitation email from me (or an appropriate email list holder) and up to two reminders will be used. If this fails to recruit appropriate numbers direct 'shout outs' at large lectures will be made (subject to the lecturers' approval). Staff participants will be by invitation based on purposive sampling on the basis of active learning practice that offers valuable insights. Student focus group participants will be selected on a first come, first served basis and will be advised of this on the information sheet.
26. Consent: Please provide <u>brief</u> details in the space to the right of how participants will be consented. You should explain why if your participants will not give consent &/or if the consent is not fully informed. You should <u>briefly</u> explain your withdrawal process	Please answer each of these questions <u>DO NOT</u> leave any answers blank Will your planned research involve individuals who are not able to give informed consent eg children (<15 yrs) or vulnerable adults? ☐ YES ☒ NO Will participants be included without explicit consent (e.g. observational studies)? ☐ YES ☒ NO Will participants get an information sheet with adequate reading time? ☒ YES ☐ NO ☐ N/A Will participants (except those just completing questionnaires) sign a consent form? ☒ YES ☐ NO ☐ N/A Will participants have the right to withdraw from the study without 'cost'? ☒ YES ☐ NO ☐ N/A Will participants have the right to withdraw and remove 'their data'? ☒ YES ☐ NO ☐ N/A Participants will be required to read and sign a consent form once they have read the participant information sheet and in advance of any data being collected. Participants will have the right to withdraw from the study at any time and to remove their data until it is anonymised.
27. Bias and positionality	Please <u>briefly</u> summarise your position and any potential bias in the study. As a university teacher with experience of considering the emotions of my own learners and talking to university teachers about theirs and their students' emotions around learning I am biased by my belief that this is aspect of interest around which awareness and support can and should be improved. I am also an advocate of active learning approaches and feel excited about their potential for building connection between students and their teachers and between peers that supports both learning and feelings of well-being. However, my research is also guided by concern that if university teachers and students are not sufficiently equipped to interact in active learning classrooms and to manage the emotions it evokes there is potential for a negative impact on well-being.
28. Summary of Method(s):	Please <u>briefly</u> (<500 words) summarise your methods. I will conduct an initial group interview with teaching team members to explore how aware they are of the emotions that they and their students experience as a result of being involved in active learning. Teachers will be asked to give their response to the

Please provide <u>brief</u> details of what you will do and what will happen to participants. There is no need to repeat details from sections 19-27 (above), but describe how they fit together and how participants will experience the study	question about how they feel about teaching the session/module and why in the form of a written response, owing to the potentially sensitive and private nature of this response. They may, or may not, choose to share this during the course of the group interview. The initial group interview will involve exploration of which emotions they are aware of, plan for and desire in active learning settings and what action they can and do take to impact this. It will include a card sort activity based on Pekrun's (1992) Control-Value Theory. Where a group interview is not appropriate I will conduct an individual interview covering the same aspects but from an individual perspective. The group interview will last no more than 90 minutes and the individual interview no more than 60 minutes. Given the COVID-19 situation, I anticipate the individual interview may, in the early research phase, be more common than planned. Rather than face to face, I will also conduct individual and group interviews using Zoom, with its encrypted recording function and a back-up hand held digital recorder. I will try to run the card sort remotely via Zoom, but if this is not possible the interview data will still be valuable. All data collection involving students directly will be scheduled from Autumn term 2020 onwards. During a taught session I will ask students to complete a questionnaire via Qualtrics (or alternative) to identify their how they feel about the session and why this might be. Students can choose whether to participate or not, will be advised that all responses are anonymous and will be handled confidentially but cannot be withdrawn from the study once submitted. Alternatively (or additionally), as decided with the teaching teams regarding the preferred/more effective approach, volunteer students will be invited to attend a focus group where they will complete a card sort activity based on Pekrun's (1992) Control Value Theory and discuss the emotions involved in learning. In order to overcome participants' reluctance to talk about their own emotions, due to the potentially sensitive and private nature of these, the emphasis will be on a card sort activity and learning emotion and its regulation in general, rather than participants' personal experiences. The focus group will last no more than 60 minutes. Once student data has been collected, anonymised and organised into themes it will be presented to the teaching team in a follow-up group interview. The teaching staff will be invited to bring additional anonymised data, collected in the business of teaching, that sheds light on learner emotion for discussion. Teaching staff will be invited to discuss patterns, surprises and contradictions in the student data, compare this to their observations and their card sort activity data and to suggest how they plan to respond to student data through educational design and facilitation. This could be arranged as an individual or group interview.
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Section C – Ethical Issues

Ethical Issues ...

*Please carefully consider these ethical issues and provide the required details using simple **LAY** terms:*

31. Risk(s) / Disadvantage(s): Please <u>briefly</u> summarise any likely 'risks' or 'disadvantages' or 'costs' that may result from participating in your study <u>Briefly</u> explain why these are justified and how they will be mitigated	What are the potential 'risks' or 'disadvantages' from participating in the study? The potential risks are that being asked to reflect on how they feel and why may lead individuals to consider aspects of their learning and/or teaching that causes them distress. In advance of the interviews and focus groups participants will be advised that they can leave at any point and their data can be withdrawn, if they wish. The potential disadvantages are loss of time for busy staff and students but every effort will be made to make the data collection experiences valuable opportunities for reflection and shared learning. Participation will not directly benefit participants in their assessments. In order that those staff and students not able to participate also benefit, guidelines will be derived from the findings and widely disseminated across the College.
32. Timing: Please <u>briefly</u> summarise any likely issues relating to timing or critical time points in your study <u>Briefly</u> explain why these are justified and how they will be mitigated or managed	Please answer each of these questions <u>DO NOT</u> leave any answers blank Have you considered and planned for key issues of timing in your study (eg important deadlines, time-critical data collection or times when participants may be busy or unavailable)? ☒ YES ☐ NO Have you thought about the timing of your study to avoid any particularly stressful or busy times for participants (such as exam times)? ☒ YES ☐ NO Have you thought about the time required to complete questionnaires, participate in interviews or focus groups etc and done your best to minimise the time inconvenience while not compromising the data collection? ☒ YES ☐ NO Do you foresee any significant delay in dissemination /publication? ☐ YES ☒ NO Do you foresee any potentially significant issues with timing? ☐ YES ☒ NO Every effort will be made to schedule interviews and focus groups at times of the academic year and of the day that are convenient to staff and students. Timing will largely be determined by the participating departments' teaching schedules. It is anticipated that group interviews with teaching staff will contribute to their developing awareness as university teachers and will therefore be considered as good use of their time. I will be guided by departmental staff as to the best time to involve their students to avoid exam and assignment submission times. Where student focus groups are held in scheduled teaching time this will be designed to contribute to students' learning about effective group working. In terms of the questionnaire, this will be designed to be completed in 10-15 minutes, during a teaching session.
33. Power:	Please answer each of these questions <u>DO NOT</u> leave any answers blank Is the researcher likely be perceived to be in a position of influence / authority over participants? ☐ YES ☒ NO Is the researcher likely to be perceived to have influence over participants' future? ☐ YES ☒ NO Will the researcher be assessing or evaluating participants? ☐ YES ☒ NO Will the researcher be teaching participants? ☒ YES ☐ NO Are there any potential conflicts of interest or what could be perceived as a conflict of interest by a reasonable observer? ☒ YES ☐ NO I am programme director of the MEd in University Learning and Teaching so some of the teaching staff participants may be current or former students. However, given that these students are already educated professionals embedded in STEM disciplines, any perceived influence on their part is like not to be significant. i.e. I am unlikely to be in a

Please <u>briefly</u> summarise any likely issues relating to power / influence in your study <u>Briefly</u> explain why these are justified and how they will be mitigated or managed	position to influence their career trajectory etc. Where teaching staff participants are still current MEd students I will mitigate against any actual or perceived power imbalance by arranging not to assess participants' summatively assessed coursework. Although I don't teach or assess undergraduate students within their disciplinary context, I can see that, as a member of Imperial staff, they may perceive me to be in a position of influence or authority over them. I will take this into consideration when giving them the option not complete the questionnaire and when facilitating the focus group.
34. Coercion: Please <u>briefly</u> summarise any likely issues relating to potential coercion in your study <u>Briefly</u> explain why these are justified and how they will be mitigated or managed	Please answer each of these questions <u>DO NOT</u> leave any answers blank Have you considered perceived and / or actual coercion? ☒ YES ☐ NO Are there any likely actual or perceived pressures such that participants may feel pressured or obliged to volunteer for the study? ☐ YES ☒ NO I do not anticipate that participants will feel coerced to participate. Although some potential teaching staff participants may be invited face to face, I will follow this conversation with an email attaching the information sheet and advise potential volunteers that they should feel comfortable to decline the invitation if they do have time to commit to the study. See box 33 regarding UGs.
35. Sensitive Issues: Please <u>briefly</u> summarise any potentially sensitive issues directly relating to your study <u>Briefly</u> explain why these are justified and how they will be mitigated or managed	Please answer each of these questions <u>DO NOT</u> leave any answers blank Is there any aspect of the proposed research that would be likely to cause reputational harm to participants, others or College? ☐ YES ☒ NO Will you be explicitly collecting sensitive or personal (primary or secondary) data such as sexual history, or records of illegal or immoral behaviour? ☐ YES ☒ NO Will personally sensitive or embarrassing issues be explicitly discussed such that participants may be unwilling to talk about them? ☐ YES ☒ NO Is it likely participants will disclose any illegal or harmful activity as a direct result of the proposed research? ☐ YES ☒ NO Will your planned research <u>focus on</u> sensitive issues such as bullying, cheating, un-professional practice (anything that may result in a strong emotional response)? ☐ YES ☒ NO If sensitive issues arise unexpectedly in interviews or similar you should seek appropriate existing professional support available and maintain confidentiality unless you have cause to suspect that the individual is a risk to themselves &/or others. In these circumstances well-being takes precedence over privacy? Please confirm you will take this approach ☒ YES ☐ NO Where data is anticipated as being sensitive, i.e. it relates to individual student and teacher emotions, it will be collected via anonymous questionnaire and written response respectively. The only potential risk in terms of sensitivity is where being asked to reflect on how they feel and why may lead individuals to consider aspects of their learning and/or teaching that causes them distress. In advance of the interviews and focus groups participants will be advised that they can leave at any point and withdraw their data up to the point it is anonymised. Should sensitive issues may arise unexpectedly, the

	participant will be encouraged to speak to their personal or senior tutor (student) or a line manager or HR representative (staff), with my help, if desired.
36. Harm: Please <u>briefly</u> summarise any potential for stress or harm to participants in your study Briefly explain why this is justified and how it will be mitigated or managed	Please answer each of these questions <u>DO NOT</u> leave any answers blank Is the study likely to result in undue stress or anxiety for participants? ☐ YES ☒ NO Does your study have the potential to harm or result in negative consequences for the participants &/or researcher(s)? ☐ YES ☒ NO The only potential for stress of participants is in being asked to reflect on how they feel and why, this may lead individuals to consider aspects of their learning and/or teaching that causes them distress. In advance of the interviews and focus groups participants will be advised that they can leave at any point and withdraw their data up to the point it is anonymised. This is balanced against the aim of the study which is to promote awareness and support regulation of emotions for learning.
37. Ethical Summary: Please provide <u>brief</u> details of the ethical issues you have identified in your study, why they are necessary and how you will mitigate against the risks There is no need to repeat details from sections 29-36 (above), but provide an integrated account of the ethical issues relevant to your proposed study and how you will manage them	Please briefly (500 words max) summarise the main ethical issues you have identified in your proposed study, why they are necessary and how you will mitigate against the risks The main ethical issues and the approaches for mitigating against them are listed below: Confidentiality – all data will be anonymised either at the point of collection (student questionnaires) or during/immediately after transcription (group/individual staff interviews or student focus groups). Identifiers and/or pseudonyms will be stored securely and separately from the data on an Imperial password-protected computer. Data and records be held securely and in accordance with Imperial guidelines and audio recordings will be deleted after the PhD exam. Risks – the main risk is the time participants give up to be involved in the study and the coinciding of timing with busy teaching and assessment periods. All efforts will be made to make the data collection activities a valuable opportunity for individual and/or collective reflection and these will be scheduled to coincide with well-aligned teaching sessions/meetings and to avoid busy teaching and assessment periods. Power and coercion – in terms of staff I have recognised the potential for perceived power and coercion but given my role and their role I see no significant perceived power imbalance or coercion that will impact their future career etc. Where participants may be student on the MEd programme, I will agree not to assess their future assessed work and will not recruit my existing MEd dissertation supervisees. Although I don't teach or assess undergraduate students within their disciplinary context, I can see that, as a member of Imperial staff, they may perceive me to be in a position of influence or authority over them. I will take this into consideration when giving them the option not complete the questionnaire and when facilitating the focus group. I will recruit and collect data from them directly rather than involving their own departmental teaching staff in the process, which may lead to perceived coercion. Sensitive issues – where data is thought to be sensitive, i.e. it relates to individual student and teacher emotions, it will be collected via anonymous questionnaire and written response respectively. The only potential risk in terms of sensitivity is where being asked to reflect on how they feel and why may lead individuals to consider aspects of their learning and/or teaching that causes them distress. In advance of the interviews and focus groups participants will be advised that they can leave at any point and withdraw their data up to the point it is anonymised. This is balanced against the aim of the study which is to promote awareness and support regulation of emotions for learning.

Section D – Documentation and Declaration

Supporting documents...

Please check the boxes for any relevant documentation that you attach to the application.

	Please attach the following documents to your application as appropriate
Participant information sheet:	☒
Participant Consent Form:	☒
Email & material inviting participation:	☒
Questionnaires:	☒
Interview / Focus Group Questions:	☒
Observation schedule:	☐
Time line or Gant Chart:	☐

Example templates for some documents are available on the website here
<http://www3.imperial.ac.uk/edudev/ethics>

Self-declaration...

Please check the boxes as appropriate for your application.

Please answer each of these questions **DO NOT** leave any answers blank

- Do you have a collaborative agreement in place? ☐ YES ☐ NO ☐ In process ☒ N/A
- Do you have a data access agreement in place? ☐ YES ☐ NO ☐ In process ☒ N/A
- Do you have a data sharing agreement in place? ☐ YES ☐ NO ☐ In process ☒ N/A
- Have you completed an Imperial College risk assessment? ☐ YES ☐ NO ☐ In process ☒ N/A
- Have you considered how you will comply with the General Data Protection Regulations when storing and handling participant data? ☒ YES ☐ NO ☐ In process ☐ N/A
- Have you had a Disclosure and Barring Service (DBS) check carried out? ☐ YES ☐ NO ☐ In process ☒ N/A
- Have you aligned your research with best practice outlined in the BERA guidelines? ☒ YES ☐ NO
- Has this work (or aspects of it) received ethical approval elsewhere? ☐ YES ☒ NO ☐ In process

If 'YES' please supply [brief](#) details below

Signatures Page - PI Declaration

I declare that:

- I undertake to abide by the ethical principles underlying the Declaration of Helsinki (1964) and subsequent amendments and good practice guidelines on the proper conduct of research.
- I undertake to abide by the Data Protection Act 2018 and General Data Protection Regulation (Europe) and any applicable local laws.
- I undertake to abide by all local laws and regulations for non-UK research.
- I will report any adverse or unforeseen events which occur to the Ethics and Research Governance Co-ordinator within 24 hours.
- I will provide an annual progress report of the project until the end of the study.
- I will provide notification of the end or early termination of the research project.
- I will provide notification of amendment to EERP / SETREC if there are any changes to the research protocol or personnel which affect the ethical aspects of the project.
- I will assist EERP / SETREC in any continuing review of the project deemed necessary by reviewers or the Committee.
- All information on this form is correct.

Name:	Kate Ippolito
Signature:	Removed
Date:	25/03/2020
If full committee review is required would you be willing to attend the SETREC meeting to answer any questions about your proposal? ☒ YES ☐ NO	

Any attendance must be by the PI named in section A of this application form. If this is a student application, the supervisor may also be present. Attendance at the meeting will give you the opportunity to answer any questions concerning ethics raised by the committee.

EERP decision (please indicate below the decision and the reasons for it)	
Decision:	Approve ☒ Reject ☐ Refer to Committee ☐
Reason:	

Required Amendments:		
Signature:		Date:

Appendix B: Table indicating relationships between later stage codes and themes

Codes for constructions of unpleasant emotion	Codes for constructions of pleasant emotion	Themes	Overarching themes
Not understanding – content too complicated	Relevancy of knowledge development to goals / interests	Emotion in evolving epistemic beliefs and goals	Knowing: Transforming epistemic goals and relationships with knowledge.
Getting lost – pace too quick	Opportunity to ask questions / clarify understanding	Teachers' relationships with disciplinary knowledge	
Falling behind – volume too high	Freedom to do what you think matters	Negotiating what is valued as knowledge	
	Catching up	Learning to cope with uncertainty	
Perceive need to know everything	Enthusiastic about content / activity	Overcoming discomfort of not knowing	
Under time pressure	Teachers value student contributions	'Controlling' knowledge in active learning	
Not knowing what to do – unfamiliar, lack of certainty	Learning felt new and challenging	Working with epistemic emotions	
Can't see value of this knowledge / skill	Practical application of theory	Scaffolding cognitive and emotional load	
Not enough challenge	Valued challenge in learning	Developing and sharing pedagogic knowledge	
	Recognise purpose of HE		

Peers are 'smarter' / Feeling stupid	Inspiring, motivating social comparison	Evaluating yourself compared to others	Evaluating: Social construction and appraisal of goal achievement
Not contributing	Contributing to peers' learning	Evaluating student achievement	
Perceived unfair contribution	Evidence of progress/achievement	Teachers being evaluated	
Concerned about nature / weighting assessment	Assessments personally meaningful		
Fear of negative judgement	Succeeding after a challenge		
Not meeting expectations	Achieving / exceeding expectations		
Don't perceive value of peer interaction/learning	Valued learning between peers		
Misalignment between learning activity/goal and personal preference	Learner and teacher goals align		
Emotions impeding success	Emotions indicating success		
Lack of emotional awareness	Emotionally aware	Students regulating their own emotions	Empathising: Reciprocal emotion regulation for complex goal achievement
Bring myself down	Normalising emotional variety	Students regulating each other's emotions	
Peers feel better	Peers feel similar		
Can't control emotion	Using ER strategies (SS, SM, AD, CC, RM)	Understanding how each other feel	
Lack of (in-person) contact	Enjoyable interactions	Teachers regulating emotion in collaborative, active learning	
Lack of empathy	Offering emotional support		

Unproductive team dynamic	Productive team dynamic	Constructing empathic goals in STEMM learning and teaching Reframing empathy for higher education contexts Teachers don't pay attention to learner emotion	
Teachers not interested in emotion	Teacher shows they care		
Lack of learner engagement	Teacher facilitates enjoyable engaging activities		
Barriers to relationship-building	Opportunity for relationship-building		
Others impede goals	Recognising other's goals		
Negative interpersonal emotional influence	Positive interpersonal emotional influence		
Teacher can't achieve goals	Teacher achieves goals		