# ***Early adolescents engaging (or not) in activities to create an e-learning module on fractions: An exploratory case study***

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A thesis submitted for the degree of *Doctor of Philosophy* at
Monash University in 2019
Faculty of Education

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**Abstract**

Many early adolescents disengage from mathematics. Learning activity engagement was explored, using case study methods, while a class of Year 8 students engaged (or not) over a sequence of lessons in co-creating an e-learning module on fractions for peers. Expectancy value theory (EVT), self-determination theory (SDT) and control value theory of achievement emotions (CVTAE) formed the theoretical framework. Data collected included exit slips, questionnaires, classroom videos, group and teacher interviews, students' animations and researcher journaling. Situational hindrances ostensibly stalled e-learning module production, but more so the researcher's assumptions were exposed by classroom realities. The students seemingly eschewed teacher-like roles involving judgement of or by known peers. Several apparent sources of student boredom were found: (a) situational (e.g., logging-in problems and Friday afternoon timeslot); (b) content-value-related (e.g., perceiving content too easy or juvenile); (c) pedagogical (passive learning); (d) social; and (e) within-individual (boredom proneness). Some students seemingly diminished self-reported engagement levels to below that observed. Conversely, many students reported most engagement when creating stop-motion animations and when 'working' (their definition unclear). The teacher and researcher thought students enjoyed exploring and discussing fractions and gradients with a simple, variably sloped runnel and a marble, but students' exit slips did not mention this. Further research is suggested: avoiding inadvertently disaffecting early adolescents; engaging early adolescents in mathematics with stop-motion animations and age-appropriate manipulatives; social effects of expressed boredom; exploring students' definitions of working and engagement; and interrogating this study's definitions and framework of engagement and disaffection pathways involving EVT, SDT and CVTAE.

## Declaration

This thesis is an original work of my research and contains no material which has been accepted for the award of any other degree or diploma at any university or equivalent institution and that, to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.

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Date: 23rd October 2019

Word count 79, 121 words

## Peer-reviewed publication during enrolment

Evans, M. (2017). Essential topics for secondary mathematics success: What mathematics teachers think. In A. Downton, S. Livy, & J. Hall (Eds.), *Proceedings of the 40th annual conference of the Mathematics Education Research Group of Australasia* (pp. 237-244). Adelaide, Australia: MERGA.[1]

[1] For ease of reference, included as the final appendix. Please See Appendix L.

## Acknowledgements

*This research was supported by an Australian Government Research Training Program (RTP) Scholarship.*

*I gratefully acknowledge the competent guidance, professional advice and detailed, timely feedback received from both Dr Karina Wilkie (main supervisor) and Dr Marc Pruyn (associate supervisor) throughout my entire candidature. Thank you, Karina, for your care, patience and expertise in helping me shape this project and through numerous rewrites. Thank you, Marc, for helping me navigate through common challenges and then to lift and steer this study to completion. Thank you both also for the freedom allowing me to try, to fail, to re-plan and then, with your encouragement and expertise, ultimately, to achieve.*

*I gratefully acknowledge the contributions from the review panellists at Monash University, mandated for all PhD students, who critically revised my research with stimulating feedback: Professor Helen Forgasz, Associate Professor Gillian Kidman; Associate Professor Ann Gervasoni, Dr Michael Henderson and Dr Hazel Tan. I am grateful for their challenges on my conceptualisation of engagement which prompted refinement.*

*Thank you to my brother, David Boschma, for valuable critiques, encouragement and helping me depict the theoretical framework visually.*

*Thank you to Serena (pseudonym), expert mathematics teacher, for welcoming me into your classroom. Your calm competence and your dedication to teaching and to your class of Year 8 students was and is an enduring source of inspiration. Thank you to the Year 8 students for their openness and participation, without which this thesis would not be possible.*

*Thank you to Dr Jennifer Hall for kindly and expertly checking my APA 6th referencing style compliance (the single quotation marks and non-compliant Level 3 headings were a deliberate choice).*

*Thank you to Richard Evans (my husband) and Ashton and Harrison Evans-Caulfield (our grandsons) for making the wooden gradient device to specifications provided by me and for making materials selections.*

*Thank you to my family and friends all of whom have encouraged me and forgiven my preoccupation with this study. I love you and am grateful for your love.*

*Thank you to my parents, Ruth and Pieter Boschma, for their loving encouragement and for being the exemplars of hard work and dedicated curiosity.*

*My special enduring gratitude, though, is to my kind and thoughtful husband, Richard, an avid reader, a community builder, a steward of the land and also an exemplar of hard work. Thank you for your abiding encouragement, support and for the sacrifices made for this thesis to come to fruition. I am fortunate to be married to a man whom I admire and love, my best friend. Thank you.*

*With gratitude for the opportunity and pride at being a postgraduate student at Monash University, I see how much I have grown and learnt, and have yet to learn.*

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# Chapter 1: Introduction

> ‘Engagement is an elusive, emergent, and multifaceted concept — one that would be difficult to measure and complex to theorize’[2]
>
> *Jacquelynne S Eccles (2016, p. 72)*

Despite historical and ongoing difficulties in defining and measuring engagement (e.g., Azevedo, 2015; Bobis, Way, Anderson, & Martin, 2016; Fredricks, Filsecker, & Lawson, 2016), there appears to be general agreement that engagement is at the heart of education, perhaps even its ‘holy grail’ (Sinatra, Heddy, & Lombardi, 2015, p. 1). Its opposite, disengagement, is therefore a serious problem and means that students are simply not learning. Unfortunately, there are multiple reports of students disengaging from mathematics, particularly early adolescents (e.g., Attard, 2013; Martin, Anderson, Bobis, Way, & Vellar, 2012; Sullivan & McDonough, 2007). In the face of widespread disengagement from mathematics, especially of early adolescents, it would seem that mathematics teachers might appreciate pragmatic information, at the activity level, of what works and what does not in engaging lower secondary students in their studies of mathematics.

Research in engagement of early adolescents in mathematics education in the 21st century lies at the confluence of different research streams: psychology; educational psychology; education; mathematics education; and educational technology. As such, I have drawn from each of these disciplines in this study. Whilst acknowledging the complexity of influences on engagement, the aim of this exploratory case study is to investigate engagement and its opposites, disengagement and disaffection, at the learning activity level (particularly with newer or less frequently used activities in mathematics education), in a Year 8 mathematics classroom while the students create an e-learning module on fractions for peers over a sequence of lessons.

[2] Reflective contemporary commentary regarding the beginnings and development of engagement as a construct in education as it was emerging in the 1990s.

### 1.1 Signposting this Chapter

In this chapter, first I outline the research context, the problem and impetus for this study — lower secondary student disengagement from mathematics. I then describe the personal context which brought me to want to study how Year 8 students respond, in terms of engagement, as they create and appraise content for an e-learning module on fractions concepts for peers. Within this, I retell vignettes and recall observations from my own life, both as a teacher and as an online mathematics course content creator. These vignettes hopefully illustrate why I came to hold some assumptions affecting and driving this study. While some of these assumptions were supported, most researcher assumptions were found, through the course of the study, to be unsupported when they met with the realities of a classroom of Year 8 students.

At this point, I need to flag that this study did not go as expected; I met with some situational impediments, but more so, early activities that were planned and based on researcher (my) assumptions, seemed to evoke unanticipated strong apprehension from some students. Other activities appeared to induce something perhaps worse — boredom. Although difficult at the time, this offered me an opportunity to gather information on students' reactions when teaching and research plans fail and when assumptions borne in one context are exposed as untrue in another.

In this chapter, following the discussion of the research context and personal impetus for the study, I state the research question, propose justifications for why this study is important and outline what will be covered in each of these chapters.

### 1.2 Background — the Problem

Many secondary students, particularly early adolescents, are not sufficiently engaging, or not being engaged, in mathematics in Australia (e.g., Attard, 2013; Martin, Way, Bobis, & Anderson, 2015; Sullivan & McDonough, 2007) and in other western nations (e.g., Balfanz & Byrnes, 2006; Megowan-Romanowicz, Middleton, Ganesh, & Joanou, 2013; Stroet, Opdenakker,

& Minnaert, 2013). As summarised by Watt and Goos (2017), disengagement in mathematics in the Australian context is associated with not achieving and not progressing with the subject, which has been borne out by a depression in comparative international testing scores in mathematics (Thomson et al., 2012) and sustained reduced numbers of students taking mathematics through upper secondary school and beyond (Forgasz, 2006a; Wilson & Mack, 2014). Poor numeracy skills limits the earnings, (Hanushek, Schwerdt, Wiederhold, & Woessmann, 2015), study, career and life choices of students (Capraro, Capraro, & Jones, 2014; Durrani & Tariq, 2012; Peters et al., 2006; Reyna & Brainerd, 2007), but also has stout implications for industry and the productivity of the nation in an ever changing economy, which is experiencing enormous and escalating technological changes and workplace upheaval (Productivity Commission, 2017, October; Tytler et al., 2008). Therefore, in the light of ongoing disengagement in mathematics with many lower secondary students, it would seem that new or seldom-utilised approaches or activities could be investigated in an attempt to engage or re-engage students so that students do not limit their own domestic, study, civic or employment prospects and can contribute strongly to the workforce.

Teachers need useful information to consider in their classrooms as to what works and what does not in engaging lower secondary students in their study of mathematics. An exploratory study on newer or seldom-used learning activities might uncover findings which can be further investigated for classroom use. Similarly, investigating newer or less frequently used learning activities, whether successful or otherwise in engaging students, may uncover new theoretical insights into engagement.

There has been widespread research on engagement and disengagement (e.g., Eccles & Wigfield, 2002; Martin et al., 2015; Skinner & Pitzer, 2012) involving multiple engagement and motivation theories (e.g., Bandura, 1991; Covington & Müeller, 2001; Deci, Vallerand, Pelletier, & Ryan, 1991; Hannula, 2006; Pajares, 1996; Schunk, 1991). It appears that since its inception in the late 1980s, the concept of engagement has evolved according to multiple influences. Theorists in educational engagement, Eccles (2016), Sinatra et al. (2015) and Boekaerts (2016), have found that there are conflicting definitions of engagement and how it relates to learning goals. Logically, if a construct is defined in multiple ways, it is more difficult to measure and improve. Exploratory research might help define what engagement is and is not.

The reasons for early adolescents disengaging in their study of mathematics are reportedly complex. Eccles et al. (1993) found that the attitudinal slump of lower secondary students was likely due, at least in part, to classroom and school practices which failed to meet some key social and psychological needs, including a degree of autonomy, opportunities for learning and social interaction in small groups and a warm personal relationship with the teacher, all of which seemed more ably met for students in primary school prior to transition. Also, concrete manipulatives have been shown to help engage students with mathematics, build conceptual understanding and to progress from concrete to representational to abstract thinking (Fyfe, McNeil, Son, & Goldstone, 2014; Loong, 2014; McNeil & Fyfe, 2012), but there is some evidence manipulatives are used less in secondary compared to primary mathematics classes (Swan & Marshall, 2010). Compounding these pedagogical and school cultural differences between primary and secondary school practices in mathematics teaching, early adolescent students appear to downplay their ability and engagement to peers and teachers for psychosocial reasons (Juvonen, 2000). Additionally, like any other group of mathematics students, early adolescents can suffer negative affect towards mathematics, including that of boredom and mathematics anxiety (e.g., Attard, Ingram, Forgasz, Leder, & Grootenboer, 2016; Grootenboer & Marshman, 2016; Sherman & Wither, 2003).

It would seem that seeking solutions to the problem of early adolescent students' disengagement from mathematics might include finding pedagogical practices that support students' psychosocial needs and by offering activities, including those using concrete or virtual manipulatives, which these students find age-appropriate and engaging. Considering evidence that young Australians use digital media avidly (Australian Bureau of Statistics, 2018), a possible avenue to explore would seem to be inviting lower secondary students to study mathematics by and through creating digital media. However, there appear to be very few studies on engaging lower secondary students in mathematics with student-generated digital media.

### 1.3 Personal Context and Impetus for the Research

As a teacher with experience spanning the primary, secondary, tertiary and further education sectors (following years in various life science roles), I came to be concerned that many students, especially lower secondary students, showed weak conceptual and procedural understanding of some fundamental mathematical concepts and could actively disengage from mathematics. The following four brief vignettes I hope demonstrate the personal context for this research and help explain where the assumptions initially driving the study have, at least partially, originated.

#### Vignette 1: Year 9 disengagement in mathematics

When first moving from primary to secondary education, I began teaching a Year 9 mathematics class midyear and found that many students could not identify the comparative magnitude of all but the most common unit fractions. From class questioning, I found that they knew that, for example, $\frac{1}{5}$ was smaller than $\frac{1}{3}$, but many did not know fluently that $\frac{2}{5}$ is smaller than $\frac{2}{3}$, and fewer still could work out that $\frac{2}{51}$ is smaller than $\frac{2}{49}$. While teaching that same class linear equations, we focussed for five to ten minutes of each session on fractions for a few weeks. Many students' relief and surprise on mastering these concepts was heartening. However, other class members appeared to have already deeply disengaged from mathematics; they expressed frustration and told me mathematics was irrelevant. 'When am I *ever* going to use this?' one student exclaimed, gesturing to the board and then his textbook, open at linear equations. My response, unfortunately, was stilted. I had not adequately considered that students might need a reason to study mathematics.

Other students in that class appeared keen for any apparent inadequacy in their knowledge to not be exposed, especially in a way that embarrassed them in front of peers. For example, another student appeared to brighten when I showed her a way to think about the equals sign as the pivot on a balance, but she shut down when she saw a classmate staring at her. It was these students whom I had failed to reach, that sparked the exploration of student disengagement. Also, as experienced by others, I felt a general sense amongst many students, particularly in mathematics, of what appeared to be a troubling lack of willingness to explore, master and succeed (see Sullivan, Tobias, & McDonough, 2006).

The topic, fractions concepts, which is both fundamental and challenging for many students (Evans, 2017), including adult learners (Baker, Czarnocha, Dias, Doyle, & Kennis, 2012; Basic Skills Agency, 1997; Reyna & Brainerd, 2007), appeared additionally confronting in that those Year 9 students, both those struggling and those more adept at mathematics, intimated this topic should have been mastered in primary school. I suspected that using concrete manipulatives that I had used with primary students would not aid engagement in the topic for these students.

**Vignette 2: Stop-motion animation**

In various classes across primary and secondary science, humanities and English education, I had used stop-motion animation projects to help engage students in the content. For example, in a Year 9 science class studying chemistry, the students made stop-motion animations of cumulative whizzing electrons in the atomic structure of the first 20 elements. Earlier, I taught a small, rural Year 3, 4, 5 and 6 class who made a stop-motion animation (using origami figures) of the eleven ships of the First Fleet making their voyage from Portsmouth in England to landing in Sydney Cove. The students appeared to enjoy having different roles — camera operator, director, model makers, model movers, colourists and researchers. On the whole, regardless of their age or the subject, these students appeared to find such projects engaging. Later I wondered if lower secondary students might find making stop-motion animations in mathematics engaging. I also wondered if making stop-motion animations or explanatory videos in mathematics would give students an ostensible excuse to use concrete manipulatives which might otherwise be deemed too juvenile for some lower secondary students.

### Vignette 3: The joy of personal discovery and rich learning conversations

Later, I was involved in writing a pre-tertiary preparatory course in mathematics. Through writing the course and having to explain and document reasoning to others, I noted my own enthusiasm when I uncovered and addressed some of my own misconceptions based on procedural, rather than conceptual knowledge of mathematics. For example, I had been taught that to convert a decimal to a percentage, the decimal is multiplied by 100 and a percentage sign is attached to the product. It had always bothered me, but the procedure produced the correct answer, so I did not spend any time querying it. However, when I 'discovered' that the decimal should be multiplied by 100% because 100% is equivalent to one and the value of the original decimal fraction is preserved, I pushed back in my chair, stared straight ahead, then inflected my head upwards while uttering a pleased, 'Ha'.

I wondered if, as occurred with me when creating a course for others, and perhaps not unlike what happens in peer tutoring (Ginsburg-Block & Fantuzzo, 1997; Worley & Naresh, 2014), middle years students might also engage with and uncover their own misunderstandings through dialoguing with classmates while creating a course for and explaining their reasoning to others. I also wondered if middle years students would have rich, engaging conversations, like I did with colleagues when creating an e-learning preparatory course on mathematics, when appraising and selecting activities, assessments and digital learning objects (DLOs) for a joint goal.

### Vignette 4: Adult students and concrete manipulatives

Finally, later again in my teaching career, when teaching undergraduate pre-service teachers in mathematics education, I noted what appeared to be ingenuous enthusiasm when students explored mathematics concepts using concrete manipulatives in the classroom. Rather than hiding the 'Aha!' moments to conceal that they had just uncovered and understood a fundamental concept, I saw students openly express joy in apparently making sense of something previously a bit perplexing. At other times, they appeared to simply enjoy exploring using the manipulatives. 'Oh, it's like magic…' said one student to another when working with a number balance. These students had an ostensible excuse to explore mathematical concepts using manipulatives: so that they could teach primary school students. I wondered what ostensible excuse could be given to lower secondary students in mathematics.

These experiences and observations have informed my interest in the study of early adolescent student engagement and of students generating and appraising digital media and other material while working towards a group goal in mathematics education.

## 1.4 Aims and Scope of the Study

An aim of this exploratory case study is to pragmatically and theoretically investigate engagement and disaffection, at the learning activity level and particularly with newer or seldom-used activities involving digital media and concrete manipulatives, in a Year 8 mathematics classroom. At the project level, an aim was to form an overarching group goal for students to give them an ostensible context to engage in learning mathematics: creating an e-learning module on fractions for peers.

As an exploratory study conducted by one researcher, the study was delimited to one Year 8 classroom and initially restricted to a 10-lesson sequence, one lesson per week or less frequently Year 8 is generally considered the end of the middle years of education (Years 5 to 8; aged 10 to 14 years). Students tend to make up their minds about their future involvement level in mathematics by about age 14, according to an Australian government review of engagement in science, technology, engineering and mathematics (STEM) subjects across the primary to secondary school transition (Tytler et al., 2008). So, Year 8 seems to be the last opportunity to influence potentially disengaged students to re-engage in their study of mathematics. The possibly disruptive year of transition in Year 7 was avoided for this study. With different activities trialled, the exploratory nature of the study was anticipated and found to be somewhat disruptive, so the length of the study needed to be long enough to gather worthwhile information, but not impinge upon other mathematics learning.

In this study, a delimitation was that learning activity engagement and disaffection were studied, and not achievement. The students were, however, asked about their learning: a pre-test was administered with the intent of using it formatively, a post-test was administered, and specific learning issues, achievements, and failures were noted in researcher (my) journaling over the course of the study. The study was delimited to the topic of fractions concepts, as informed by the results of a preliminary study (Evans, 2017) which found that mathematics teachers ($n$ = 30) highlighted this topic as critical for students' success and in which students needed more fluency and conceptual understanding. A further delimitation of the study was that the class needed to have an expert mathematics teacher so that issues of pedagogy and classroom behaviour would be managed, and his/her expertise could be drawn upon to help shape or at least appraise the activities from his/her perspective.

### 1.5 Research Questions

With the scope outlined above and the aim of pragmatically and theoretically investigating engagement and disaffection at the learning activity level, and with a focus on student-generated or appraised digital learning media and concrete manipulatives, the research questions are as follows:

- What activities, activity characteristics and conditions seem to be engaging for these Year 8 mathematics students while co-creating an e-learning module on fractions?
- What activities, activity characteristics and conditions seem to be boring, or otherwise disaffecting or disengaging, for these Year 8 mathematics students while co-creating an e-learning module on fractions?

### 1.6 Relevance of and Justification for this Study

Engagement as a research construct, from its emergence in the mid-1980s to now, has not yet been consistently defined and theorised in the educational psychology literature (Azevedo, 2015; Boekaerts, 2016; Eccles, 2016). Despite enormous advances in psychology and education research in the past 30 years, the trend of widespread disengagement of middle years students in industrialised nations in mathematics appears not to be abating (e.g.,  Martin et al., 2015; Middleton, 2013; Sullivan, Tobias, et al., 2006). Trialling and exploring relatively new or seldom-used activities in studying mathematics might elicit new insights.

To date there seems to be very little research on engaging early adolescent students as content creators using contemporary 21st century technology, especially in mathematics. There is research on engaging tertiary students with student-generated digital media in science and science education (e.g., Hoban & Nielsen, 2013; Kidman, Keast, & Cooper, 2013) and in mathematics education using mathscasts — narrated explanatory video screencasts of mathematics concepts and procedures (Galligan, Hobohm, & Peake, 2017), but there appears to be very little research on student-generated digital media in school mathematics, with some exceptions (Hoban, 2005). To illustrate, in a recent search I conducted using the US education database, Education Resources Information Centre (ERIC) I combined the ERIC main subject search terms: ‘student developed materials’(1,640 results); and ‘educational technology’ (44,495 results); and ‘mathematics education’ (24,893 results). This search returned only one result for student-developed educational technology materials in mathematics. The same search in science education returned 43 results. Hoban (2016, p. 25), who has led research in student-generated media with university science students, claims that student-generated digital media is both ‘under-utilised and under-researched’. It would appear that an exploratory study on engagement of lower secondary students using student-generated digital media in mathematics is warranted.

The use of digital technology for this study seems justifiable in terms of current school-student interest and uptake. According to Ainley (2011), for several decades Australian students have been using information and communication technology (ICT) more than, and with greater ability, than the majority of their international peers. The Australian Bureau of Statistics (2016) (ABS) report, ‘*8146.0 Household Use of Information Technology (HUIT), Australia, 2014 – 2015’*, showed that young Australians aged 15 – 17 years (the youngest age group surveyed) had a mean average weekly use of the internet, mainly for social networking, but including for educational use, of 18 hours per week (this question was not asked in the most recent iteration of the ABS survey). In contrast to what appears to be happening in regard to technology use in the home and in private use for young people, technology use in the classroom appears not to be strongly participant driven.

According Wang, Hsu, Reeves, and Coster (2014), technology use in classrooms could be more student-centred and participatory. One of the eighteen trends and recommendations of 2017 K-12 report by the New Media Consortium and the Consortium for School Networking (Freeman, Adams Becker, Cummins, Davis, & Hall Giesinger, 2017), is that students become digital creators, not just digital consumers: ‘Schools are challenged to provide students with opportunities to produce their own content, which allows learners to experience firsthand how knowledge is constructed and disseminated’ (p.28).

In regards to teacher professional learning and use of technology in classrooms, it appears that technology integration in primary and secondary schools is centred on teachers directing the technology use and this practice has not had the anticipated impact on students’ learning (Wang et al., 2014). Additionally, pre-service teachers expect to use more technology in their classrooms than they experienced as students themselves (Fluck & Dowden, 2013). Within this expectation of more technology use within the classroom and a reported trend and recommendation for technology to be used creatively in schools, it would appear warranted to explore the engagement of students in mathematics while they create digital media.

Studies internationally (Middleton, 2013; $n$ = 21,159) and nationally (Martin et al., 2012; $n$ = 1,601) have found that engagement and motivation in mathematics are directly related to students’ interest in mathematics, students’ perceived utility or value of mathematics and their self-efficacy (self-rating of competence) in mathematics. Additionally, Martin and colleagues (2012) found that enjoyment of mathematics had the strongest within-individual and overall correlation against disengagement and with wanting to undertake further studies in the subject. Martin and colleagues also found that individual engagement in mathematics was somewhat dependent on the perceived enjoyment of classmates. This seems to suggest that at least some activities should not be only individually enjoyable but should be visibly enjoyable to others to engender engagement. It would appear that investigating activities which young secondary students find intrinsically engaging and visibly enjoyable would be fruitful and, as suggested here, needed.

In this study, I intended to research if and how giving the Year 8 students fresh opportunities to succeed, while attention was drawn away from individual achievements and towards a relevant and challenging group goal (Locke & Latham, 2006), might assist them with engaging with learning mathematics and not on any previous negative experiences with the subject. As discussed in the findings, it was found that this approach was largely not successful in this study’s context, and the likely elements undermining its success have been fascinating to uncover.

It should be noted that not all of the approaches employed in the study were novel or seldom used. In the study I also employed a mixture of pedagogical approaches, most of which the students would likely have encountered in their nine years of schooling, which have been found to be effective in mathematics education: (a) group work (Goos, Galbraith, & Renshaw, 2002); (b) group mathematics discourse (Cengiz, Kline, & Grant, 2011; Hintz, 2013; Quebec Fuentes, 2013; Weber, Maher, Powell, & Lee, 2008); (c) linking mathematical concepts to promote deeper thinking (Ketterlin-Geller, Chard, & Fien, 2008; Stigler & Hiebert, 2004); and traditional lecture (Reynolds & Muijs, 1999) interspersed with short activities, like think-pair-share (Lyman, 1981). What was not known was whether incorporation of these approaches within this study would be engaging or otherwise with these students.

It was planned that the learning activities in this study, including those which involved digital technologies, were not to be comparatively or normatively assessed, but undertaken in small groups with task achievement goals, not assessment goals (although administering the pre- and post-tests for research purposes may have confounded this intention from the students’ viewpoints). Both an overall goal — creating an e-learning module on fractions for peers — and proximal small-group goals, for example, creating a stop-motion animation linking two fractions concepts, were offered. It was intended this would provide meaning, value and purpose to the learning, and therefore be engaging. What was not known was whether students would actually find these small-group task-based goals approach engaging, meaningful, purposeful and enjoyable.

This study on engagement of Year 8 mathematics students, while they appraised or created digital media for an e-learning module on fractions for peers, appears justified. It explored engagement of students under an intended bonding and validating group objective. It incorporated activities found to be fruitful in mathematics education (group work, mathematics discourse and cross-concept exploration) with those for which there appear to be relatively few previous studies in mathematics education — students generating stop-motion animations and other digital media, particularly using concrete materials, and appraising digital learning objects (DLOs).

### 1.7 Thesis Outline

After this chapter, there are three literature review chapters.

In Chapter 2: Student-Generated Media and Fractions Concepts, I discuss the apparently seldom-used pedagogical approach explored in this study, student-generated media, with an emphasis on stop-motion animation and a discussion on why it might be engaging for students. Next, I discuss fractions concepts and how I came to select the concepts of part-whole, ratio and measure, plus the construct equivalence, to be topics for the students to explore and for which to create digital media.

In Chapter 3: Influences on Engagement, I consider a range of influences which have been shown to affect engagement and which I thought might have prior or ongoing effects on learning activity engagement in this study. I discuss the following: (a) affective domain, including a more detailed examination of the emotions of anxiety, enjoyment and boredom and the control value theory of achievement emotions (Pekrun, 2006); (b) self-efficacy in mathematics; (c) determinants included in Martin’s (2007a) Motivation and Engagement Wheel; (d) adolescent traits; (e) teacher effects and pedagogies; and (f) physical or environmental influences.

In Chapter 4: Defining Engagement and the Theoretical Framework, I outline what two educational psychology theorists (Boekaerts, 2016; Eccles, 2016) have noted is needed for researching engagement in education contexts. Then, engagement and motivation are overviewed and defined, particularly in relation to needs and goals, and disaffection is defined and contrasted with disengagement and compliant engagement. The 'grain size' of engagement is explained and I review the literature on emotions pertinent to engagement, particularly enjoyment and boredom. Next, the theoretical framework this study, focussed at the level of learning activity engagement, is explained. It draws on expectancy value theory (Eccles et al., 1983; Wigfield & Eccles, 2000), self-determination theory (Deci & Ryan, 2000) and the control value theory of achievement emotions (Pekrun, 2006) and shows proposed links among these theories.

In Chapter 5: Research Philosophy, Methodology and Methods, I explain how the study was designed to address the central research questions — 'What activities, activity characteristics and conditions seem to be engaging for these Year 8 mathematics students while co-creating an e-learning module on fractions?' and 'What activities, activity characteristics and conditions seem to be boring, or otherwise disaffecting or disengaging, for these Year 8 mathematics students while co-creating an e-learning module on fractions?' I discuss the tenets of qualitative research and explain the pragmatic ontology, epistemology and axiology of the study. The utility of a case study for this work is outlined, as is the role of the researcher. I explain how the issues of trustworthiness and validity (Creswell, 2013) were addressed in this study. A range of data collection methods, elicited from different participants' perspectives, is described. Additionally, the data analysis procedures are explained: (a) the process of coding qualitative responses using NVivo; and (b) analysis and display of students' responses using Excel. Also, in this chapter I define the setting for the study, set the delimitations, describe Rivertown High School (pseudonym) and introduce the expert mathematics classroom teacher, Serena (pseudonyms are used throughout this study), and her class of Year 8 students.

There are three findings and discussion chapters.

In Chapter 6: Tensions — When Researcher Assumptions Meet Classroom Realities, I show and discuss some students' averse responses which were, for me, counter to expectations. Also, in Chapter 6, I explain some situational hindrances, and I surmise that the combination of both negative reactions and situational difficulties thwarted the completion of the e-learning module. Nonetheless, the tension between the researcher (my) expectations and the reactions and conditions encountered in the classroom produced some interesting results.

In Chapter 7: Disaffection — Expressions of Boredom, I show and discuss activities and conditions which seemed to elicit boredom and other disaffection in the students. I explain evidence which seems to indicate that one or maybe two students were boredom prone (experience everything but the most exciting events as boring) and that some students appeared to express more boredom than what was observed from their behaviour. Using the model of the theoretical framework, I show and explain the possible routes to disaffection and to, a perhaps more intractable condition, disengagement.

In Chapter 8: Engagement — 'the funner stuff like stop motion and all that', I show and discuss activities which seemed to elicit engagement in the students including stop motion animation, releasing a small ball down the variable slope of a simple gradient device and mathematics discourse involving linking concepts. Using the model of the theoretical framework, I show and explain how engagement might operate and discuss how extrinsic motivators might draw students towards goals parallel to the learning goal.

In the final chapter, Chapter 9: Implications and Conclusion, the limitations of the study are discussed, and the proposed implications are separated into practical, methodological and theoretical considerations. The practical implications include discussion of the tasks, the concrete manipulatives used and the environmental, pedagogical, socially driven and within-person effects on the students' engagement. The methodological implications for conducting classroom-based research on engagement of early adolescents are specified. The theoretical implications include discussion of the definitions used in this study of engagement and disaffection; and a final graphical depiction and discussion of the proposed additions to the theoretical framework used in this study including extra proposed pathways as suggested by the data.

# Chapter 2: Student-Generated Media and Fractions Concepts

In this study, I explored the level of engagement in activities of a class of Year 8 students while they created and selected digital media for an e-learning module in fractions. I have split the discussion of the literature into three chapters. In this, the first of the three literature review chapters, I discuss student-generated media and fractions concepts which pertain specifically to this study. In Chapter 3: Influences on Engagement, I discuss a broad range of background factors which have been found to influence engagement. This leads to the theoretical discussion on engagement covered in the final literature review chapter, Chapter 4: Defining Engagement and the Theoretical Framework.

## 2.1 Signposting this Chapter

In this chapter, I discuss two areas of literature relevant to this study: (a) student-generated digital media; and (b) fractions concepts.

In section 2.2 Student-Generated Digital Media, when discussing student-generated digital media, due to the apparent dearth of research in this area in secondary mathematics education, I draw on work by Hoban (2005; 2016b) and others in tertiary science education and also discuss engagement in terms of creativity.

In section 2.3 Fractions Concepts, I especially draw upon work by Kieren (1976), Behr, Lesh, Post, and Silver (1983) and Charalambous and Pitta-Pantazi (2007).

## 2.2 Student-Generated Digital Media

Digital cameras, video cameras and related software became more affordable at the turn of the millennium (Clark, Hosticka, & Bedell, 2000), and it appears that at that time student-generated digital media started being considered as a viable pedagogical approach (Hoban, 2016a). Hoban (2005) used slow stop-motion animation — which he coined ‘slowmation’ (a progression of slow moving frames, 1-2 frames/second, that build to create the illusion of movement) at first with primary school students and since with tertiary science and pre-service science education students (Hoban, 2016b) to help them engage with, discuss, comprehend and communicate scientific processes. Other student-generated digital media forms include podcasts (sound only — narration, music, atmospheric and special effect sounds), digital stories (narrated still digital presentation slides), videos (fast moving images and narration), screencasts (narrated video screen capture) and blended media (combinations of all those mentioned including the use of screen-casting apps allowing students to draw on a range of media).

### Youth time on digital devices

According to census data (Australian Bureau of Statistics, 2016, 2018), Australian youth (15 to 17 years) spends an average of 18 hours per week using the internet (therefore using a digital device), mainly for social networking (93%), entertainment (92%), and formal education (79%). This is comparatively higher weekly use than adults. For example, adults aged 45-54 years spent an average of 7 hours per week on the Internet (ABS, 2016) mainly for banking (71%), social networking (62%) and online shopping (60%). Young Australians appear to be expert and willing users of digital devices in readily accessing and uploading to FaceBook, YouTube, Instagram, and SnapChat (Ainley, 2011). With world-leading levels of access to digital devices in the home and the classroom, Australian 15-year-old students perform better than most other Organisation for Economic Cooperation and Development countries in digital reading ability (OECD, 2015). In the US, Squire and Dikkers (2012) found that secondary school-aged students given smart devices (iPhones) with unlimited plans augmented their learning and social connectivity productively. Considering that given the opportunity, young people use and create digital media in their personal time, it is surprising that there appears to be only emerging research in student-generated digital media in education.

### Student-generated digital media in the literature

There is worthwhile and helpful research and advice on engaging middle years students with existing digital media and digital applications (e.g., Attard, 2011b; Attard & Northcote, 2011; Bray & Tangney, 2016; Hepplestone, Holden, Irwin, Parkin, & Thorpe, 2011; Perry & Steck, 2015), including using digital games (Deater-Deckard, Chang, & Evans, 2013; Gresalfi, Rittle-Johnson, Loehr, & Nichols, 2017; Habgood & Ainsworth, 2011; Núñez Castellar, All, De Marez, & Van Looy, 2015) but far fewer research articles on students actually *creating* digital media.

In the extant literature, there are salient articles on student-generated digital media used as a pedagogical or assessment tool with tertiary science and science education students (e.g., Hoban, Loughran, & Nielsen, 2011; Hoban & Nielsen, 2010; Kidman et al., 2013; Nielsen & Hoban, 2015; Rifkin & Hine, 2016), but very few in tertiary education of mathematics (e.g., Galligan et al., 2017). While some are available (e.g., Henderson et al., 2010; Hoban, 2005; Prain & Waldrip, 2006), there seems to be surprisingly few research papers on student-generated media in primary and secondary schools, although more research using screen-casting apps, like Explain Everything, seem to be emerging, particularly in the professional literature. In mathematics education, research in student-generated digital media with lower secondary school students is even more scant with some notable exceptions (e.g., Diamantidis, Kynigos, & Papadopoulos, 2019, February; Freeman, Higgins, & Horney, 2016; Hanson, 2013; Lazarus & Roulet, 2013). I could not discover any research in *engagement* of lower secondary students using student-generated digital media, regardless of the subject.

### Why classroom use of new technologies for student-generated media may not yet be widely accepted

As discussed by Borba and Villarreal (2005), and still apparently relevant over a decade later, there is a discrepancy between the amazing array of technology available and the relative lack of use of it in mathematics classrooms. However, as Borba and Villarreal explain, when new technologies are implemented — going back to viewing writing itself as a new technology, to using ink and paper, to the printing press, and now to computers and the internet — perhaps this is to be expected. They state that humans have to be at one with technology for it to be used in a particular context. As clarified in the heavily-cited article by Davis (1989) three decades ago, technology needs to be perceived as useful (have a need met), perceived as easy to use and accepted by users in a particular context for it to be used. For example, taking and sharing photos and videos on a smartphone via social media is perceived as useful for social interaction, easy (it would be quaint, inconvenient and expensive now to take a photograph with a film camera, have it developed and printed, then sent via post) and the technology is so widely accepted and users so at one with it, that its overuse has become a societal problem (Billieux, Maurage, Lopez-Fernandez, Kuss, & Griffiths, 2015).

Mathematics education seems to have maintained a milieu of teacher-centric pedagogy (see Attard & Northcote, 2011; Wang et al., 2014) and it appears many teachers tend to use technology for showing and explaining, for example, showing videos and explaining digital slide presentations (Drijvers, Doorman, Boon, Reed, & Gravemeijer, 2010), and to reduce the tedium of pen-and-paper calculations, for practicing skills and for aiding conceptual understanding (Drijvers, 2015). So, although used, technology in mathematics classrooms does not seem to be widely used for creation, innovation and collaboration. As stated by Clark-Wilson, Robutti, and Sinclair (2014), 'despite over 20 years of research and curriculum development concerning the use of technology in mathematics classrooms, there has been relatively little impact on students' experiences of learning mathematics in the transformative way that was initially anticipated' (p. 1). Therefore, in many mathematics classrooms, particularly in didactic, teacher-centred classrooms which appear to be still prevalent, neither teachers nor students appear to be at one with *creative* technology use.  As such, student-generated digital media is not a typical pedagogical approach used in lower secondary mathematics.

It appears that in order to affect change, there needs to be measurable benefits which are demonstrable in terms of both engagement and achievement (see Nielsen, 2016), and the will, confidence, institutional culture, professional development and support (Rifkin & Hine, 2016) for teachers to give over the responsibility and control of content creation to students. In the context of academics delivering units in university science education, it is ‘clear academics are not differentiating technology-for-content-delivery from technology-enabling-student-creativity’ (Rifkin & Hine, 2016, p. 20). According to Wang et al. (2014) and it seems a similar statement could be made about the context of many secondary mathematics classroom teachers delivering curriculum mathematics in schools.

It appears that teachers and institutions that adopt a student-centred, integrated social constructivist pedagogy (Bray & Tangney, 2016; Harris & Alexander, 1998) which focus on mathematics as a creative, project-based, collaborative and hands-on venture (Boaler, 2016) might consider student-generated digital media as an approach. As described by Hoban (2016b) regarding university students using student-generated digital media in science classes, there are four reasons for teachers to consider this pedagogy: (a) students find it engaging; (b) students develop 21st century skills in digital literacy; (c) it effectively helps students learn; and (d) it allows students to be creative. Although all four reasons would seem to have merit, the affordance of engagement and creativity with students generating digital media is of particular relevance to this study.

**Engaging students with creating digital media**

For Hoban (2016b), tertiary students find creating digital media engaging because it is participatory and because the technology is familiar (largely through students using social media). These same benefits would seem to apply to secondary students and would suggest that secondary students would also find creating digital media engaging. Also, it would appear that, for Hoban, creativity is engaging for students. But what is creativity and why might it be engaging?

**Defining creativity**

Aldous (2007, p. 176) has investigated creativity in mathematics and science by examining four sources: ‘(a) historical and introspective accounts of novel problem solving by noted scientists [e.g., Einstein] and mathematicians; (b) cognitive psychology and neuroscience;’ (c) her study which found that expert problem-solvers reported not being consciously aware of logical processing to solve novel problems; and (d) an exploration of education literature on the definition of creativity. According to Aldous (2007, p. 177), the definition of creativity most used in education, is 'the production of effective novelty'. That is, something is produced, it is useful, unique and new. Producing an explanatory video or a stop-motion animation would seem to satisfy these criteria. Aldous further explains that creativity in educational settings is relative to the originator. So, if students produce a solution to a mathematics problem via a new-to-them approach or a produce a presentation or animation which they have not produced before, it is considered creative.

Silver (1997), in his highly cited paper, has railed against the approach of drawing on the experiences of mathematical and scientific geniuses to conceptualise mathematical creativity because it characterises creativity as a rare, effortless and mysterious (pre-conscious) phenomena of the gifted. Rather, he argues in mathematics education for 'a form of instructional activity that is enriched by concepts connected to the notion of creativity' (Silver, 1997; p. 75) and holds that creativity can be taught. Citing Torrance (1972), Silver explains that creativity has three components and all three apply to mathematics problem solving: (a) fluency (finding numerous ideas in response to a problem); (b) flexibility (adaptively using different approaches to solve the problem); and (c) novelty (coming up with innovative ideas to solve the problem). So, for Silver, when mathematics teachers pose rich and challenging (and often open-ended) problems, students learn and practise creativity. Accordingly, a problem-solving, inquiry-oriented approach in mathematics requires and fosters adaptive facility and originality. That is, such an approach fosters creativity in mathematics. It seems that students producing effective novelty *and* solving rich, challenging problems are not incompatible.

Creativity is adaptive. As posited by O'Byrne et al. (2018, p. 184), 'without creativity, we could hypothesize that we all would still be living in the "caveman" days with a primary focus on our existence and survival'. Aldous (2007) found ($n$ = 405) that creativity involves three activities: 'the interaction between visual-spatial and analytical-verbal reasoning; attending to feeling in listening to the 'self'; and the interaction between conscious and non-conscious reasoning' (pp. 179-

180). It seems that creating digital media involves interaction between visual and spatial elements and reasoning, but whether it involves listening to the inner self and attending to conscious and pre-conscious reasoning is less apparent. Perhaps pointing a video camera at a subject and pressing the record button would not be deemed creative, but planning, explaining and making a video about challenging one's own misconceptions in mathematics or making a stop motion animation linking three representations of fractions would be creative.

## 2.3 Fractions Concepts

To engage lower secondary students in a 10-lesson project focusing on fundamental, but still challenging, mathematics, the topic needed to be selected carefully. Ideally, to enhance the project's relevance, value and wider appeal, the topic needed to be one on which other more complex topics depend and is demonstrably essential and therefore valuable to school mathematics, further education, civic life, and the workplace. Enough students needed to have some degree of difficulty with the topic such that the finished product, an e-learning module, would be seen as a potentially worthwhile and challenging project to work on and a meaningful resource for end-users. In order to willingly commit to the research project, the mathematics teacher involved in the study also needed to be able to appraise the topic as worthy of expending effort, time and resources.

Previous research supports that intervention on the topic of fractions is needed as it is often poorly understood across a broad spectrum of learners: primary school students (Daraganova & Ainley, 2012; Zhang, Clements, & Ellerton, 2015); middle years (Years 5 to 8) students (Clarke & Roche, 2009; Stafylidou & Vosniadou, 2004); more senior secondary school students (Brown & Quinn, 2006; Kloosterman, 2010); pre-service teachers of primary and secondary mathematics (Ball, 1990; Castro-Rodríguez, Pitta-Pantazi, Rico, & Gómez, 2016; Chinnappan & Forrester, 2014; Harvey, 2012) and the general public (Basic Skills Agency, 1997; Reyna & Brainerd, 2008). Indicating that difficulties in understanding fractions starts early, the Longitudinal Study of Australian Children, Annual Statistical Report 2011 (Daraganova & Ainley, 2012) included primary school teachers' ratings (*n* = 3,533) of children's numeracy skills (aged 8 to 9 years) and found that a quarter of children had either not yet (7%) or were just beginning (16%) to form an age-appropriate concept of fractions compared to, for example, half that amount either not yet (3%) or just beginning (9%) to form an age-appropriate concept of place value.

It seems that difficulties with fractions concepts persist for lower secondary students. In an open questionnaire asking Australian middle years students themselves (Years 5 to 8; *n* = 3,562) about their single most important aspiration in mathematics, Wilkie and Sullivan (2018) found that increased understanding of fractions, decimals and percentages was the highest response. Lastly, Evans (2017) found that, from a range of fundamental mathematics topics, mathematics teachers (*n* = 30) rated fractions concepts as the topic which is most critical for success and was that in which the teachers rated students need more fluency and more conceptual understanding compared to other topics. Therefore, the topic chosen for the Year 8 students to co-create an e-learning module was fractions concepts.

One of the main reasons posited that fractions are difficult to learn and teach is that fractions as a construct is not comprised of one concept, but of several interrelated, and often themselves multifaceted, sub-concepts: part-whole, measure, ratio, quotient and operator (Behr et al., 1983; Charalambous & Pitta-Pantazi, 2007; Kieren, 1993; Kieren, 1976; Lamon, 2012). The fractions concepts model first conceived by Kieren (1976), with modifications by Behr et al. (1983) and later by Charalambous and Pitta-Pantazi (2007), provided the framework for which students involved in this study created some digital media to help build an e-learning module on fractions. Additionally, according to Hattie, Fisher, and Frey (2017), Skemp (2006) and Pape and Tchoshanov (2001) when students explore connecting ideas between concepts, this can help them develop deep learning of a topic and this deep learning is profoundly engaging, so I also explain from the literature what was helpful in determining the connecting ideas across the fractions concepts.

### Fractions concepts models

In this sub-section, I outline fractions concepts models in the literature and explain what was helpful in selecting particular fractions concepts for the Year 8 students to explore and represent or appraise visually in digital format (animation or video). In the determining work by Kieren (1976), he argued that rational numbers (numbers which can be written in fraction form as a ratio of two integers, so includes all fractions) comprise the *part-whole concept* and seven (non-exhaustive) additional interpretations:

1. Fractions can be compared in magnitude, and can be added, subtracted, multiplied and divided
2. 'Rational numbers are decimal fractions' (p. 102), and as such, are a natural extension of the base-ten numeration system and the whole number system
3. 'Rational numbers are equivalence classes of fractions' (p. 103)

   e.g., $\frac{2}{3}, \frac{4}{6}, \frac{6}{9}, \frac{8}{12} \ldots \frac{200}{300}$ etc. are a set all with the same value
4. Rational numbers are ratios 'in the form p/q where p and q are integers and q ≠ 0' (p.103)

   e.g., $\frac{2}{3}$ can be seen as a ratio between the number of equal parts in question, 2, and the total number of equal parts which the referent whole has been divided, 3
5. 'Rational numbers are multiplicative operators' or 'stretchers' and 'shrinkers' (p.103)

   e.g., For $\frac{2}{3} \times 12 = 8$, the 12 has been shrunk to $\frac{2}{3}$ of its original size to give 8

   e.g., For $\frac{3}{2} \times 12 = 18$, the 12 has been magnified by $\frac{3}{2}$ to give 18
6. 'Rational numbers are elements of an infinite ordered quotient field. They are numbers of the form $x = \frac{p}{q}$ where *x* satisfies the equation $qx = p$' (p. 103). That is, rational numbers, which include fractions, are the result of a division of two integers, and all possible quotients form the field of rational numbers which is ordered, and infinite in both magnitude and density.
7. 'Rational numbers are measures or points on a number line.' (p. 103)

For Kieren (1976), these seven interpretations of fractions are conceptually built upon, and subordinate to, the part-whole concept. The part-whole concept involves partitioning or dividing a whole (a set, quantity or unit) into equal shares. These concepts will be explained further below.

Behr et al. (1983) modified Kieren's (1976) interpretations into five fractions sub-concepts (part-whole/partitioning, ratio, quotient, operator and measure) as well as additive and multiplicative operations, equivalence and problem-solving. Charalambous and Pitta-Pantazi (2007) wanted to know how students learn and inter-relate fractions concepts. They tested Behr and colleagues' model by assessing Cypriot upper primary school students' ($n$ = 646) construction of fractions knowledge, and, using structural equation modelling (SEM), analysed the relationships between each of the five fractions sub-concepts, additive and multiplicative operations, and equivalence (but omitted problem-solving in the modelling).

Charalambous and Pitta-Pantazi (2007) largely found support for the Behr et al. (1983) fractions concepts model, in that mastery of the concept of ratios appears to help students find equivalent fractions. Two sub-concepts, number lines (a sub-concept of measure) and adding dissimilar fractions, were also found to be linked to equivalence. Please refer to Figure 2.1 and note that where the researchers found empirical support only for specific elements of a sub-construct, that is, of number line tasks under the construct of measure and adding dissimilar fractions under additive operations, that relationship has been depicted with a dotted line.

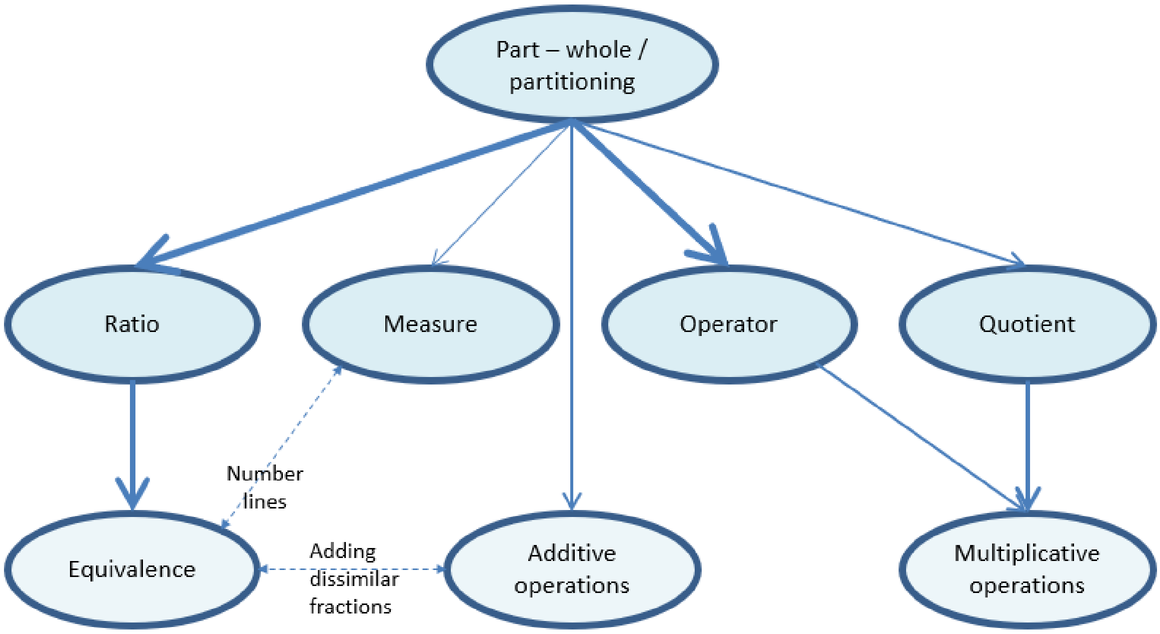



*Figure 2.1.* Structural model linking the five concepts of fractions to equivalence and operations of fractions, with arrow width showing approximate relationship strength. Adapted from 'Drawing on a theoretical model to study students' understandings of fractions,' by C. Y. Charalambous and D. Pitta-Pantazi, 2007, *Educational Studies in Mathematics, 64*(3), p. 306. Copyright 2006 by Springer. Adapted with permission.

This model helped me prioritise, bundle and choose the fraction concepts to invite students to create digital media for the e-learning module for peers. I did not anticipate that the students would be able to cover all fractions concepts and operations in the creation of the module in 10 teaching sessions. Given the centrality of the part-whole concept, I planned to start there and look to the literature for part-whole concepts on which lower secondary students might possibly need extra learning time or support. Next, from the model I could see that ratio concepts, which are introduced in the Australian Curriculum at Years 7 and 8 (Australian Curriculum Assessment and Reporting Authority, n.d.-a), relate strongly to both the concepts of part-whole and of equivalence and would appear to be a logical inclusion. Lastly, the idea of comparing fractions on a number line, within the concept of measure, was found to be related to equivalence (Charalambous & Pitta-Pantazi, 2007), which is an important fractions sub-concept (Clarke & Roche, 2009; Ni, 2001). As discussed below, researchers have found that comparing the magnitude of fractions and being able to place them on a number line seems to be an efficient indicator of students' understanding of fractions in general (Clarke & Roche, 2009; Siegler, Thompson, & Schneider, 2011; Torbeyns, Schneider, Xin, & Siegler, 2014).

As shown in Figure 2.2, I bundled the following fractions concepts for students to create digital media for in this study: part-whole/partitioning, ratio, equivalence and measure.

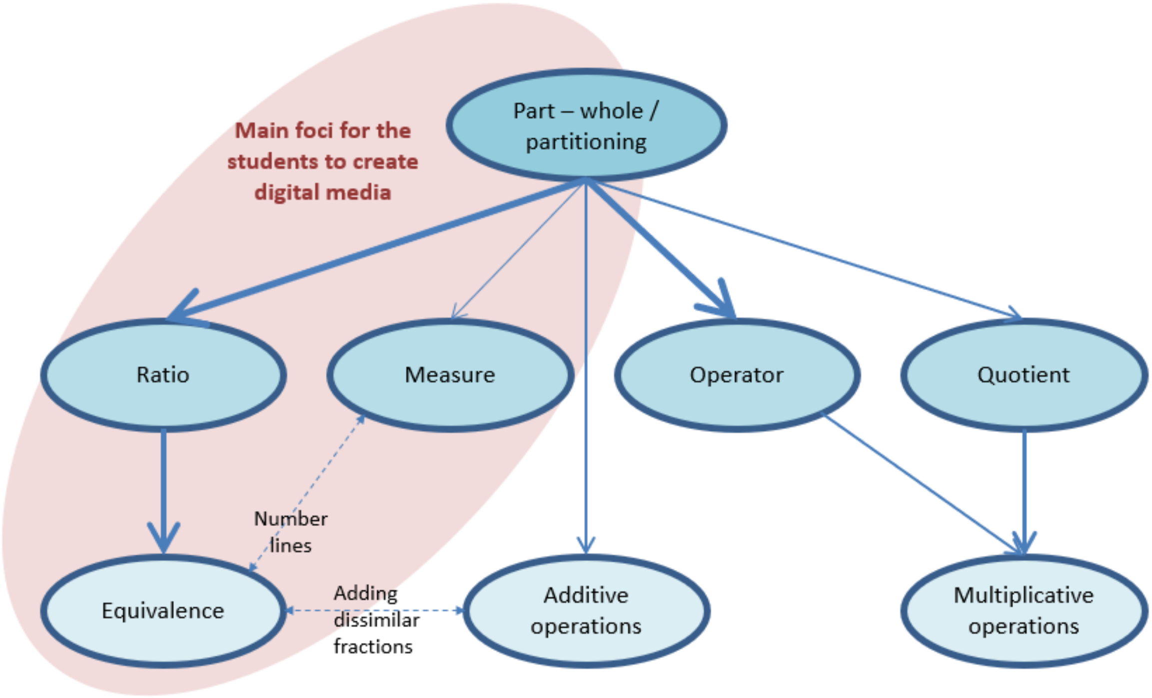



*Figure 2.2.* Model showing sub-concepts and operations of fractions for which students were asked to create digital media in this study. Adapted from 'Drawing on a theoretical model to study students' understandings of fractions,' by C. Y. Charalambous and D. Pitta-Pantazi, 2007, *Educational Studies in Mathematics, 64*(3), p. 306. Copyright 2006 by Springer. Adapted with permission.

I planned to give the students an overview of all the sub-concepts but focus on the selected group of fractions concepts for creation of the e-learning module. Each of the five fractions concepts and equivalence are explained below in reference to the literature, concentrating on those for which the students were asked to create digital media. The operations of addition and multiplication of fractions are not discussed because it was beyond the scope of this study to cover fractions operations.

**The part-whole/partitioning concept**

The part-whole concept involves partitioning (dividing) a whole into equal parts, with both discrete (countable sets) and continuous quantities (like length and area). Students need to make sense of the two numbers of the fraction (Kieren, 1976) – the numerator (top number) showing the number of parts held and the denominator (bottom number) showing how many equal parts the whole has been divided.

Students often exhibit whole number bias (Ni & Zhou, 2005; Siegler et al., 2011), that is, treat a fraction as two separate whole numbers rather than as a relationship between a part and a whole or as a number in itself with a value. Students need to understand that as the numerator increases, the value of the fraction increases, and as the denominator increases, the opposite happens, the value of the fraction decreases (Lamon, 2012; Siegler & Pyke, 2013; Siegler et al., 2011). In a part-whole context, this can be explored by noting that more, smaller fractions (with greater denominators) fit into a whole than larger fractions with smaller numerals as denominators. Lamon (2012) describes that understanding inverse proportions relates to all the fractions concepts and as such it was included in this study for the students to explore connections deeply and thereby engage in their learning.

As noted above, Charalambous and Pitta-Pantazi (2007) found evidence concurring with the models of Kieren (1976) and (Behr et al., 1983) that the part-whole concept is central to students' understanding and connected to all of the other sub-constructs, although they found it is most strongly connected with ratio and operator sub-constructs. This centrality could be because the part-whole concept is that which is most often encountered or it could be that it is semantically or developmentally essential to students' understanding of fractions (Charalambous & Pitta-Pantazi, 2007).

In order to make sense of the part-whole concept, students need to understand and identify the referent unit (Lamon, 2012). Presenting fractions often or only with a single round shape (often pizza or cake) as the referent unit, will not fully develop this concept (Lamon, 2012). Furthermore, over exposure to the part-whole concept, particularly where the referent unit is a single round object, can over-expose students to fractions below one (Lamon, 2012) such that they become unfamiliar with improper (top heavy) fractions (Clarke, Roche, & Mitchell, 2008). In this study, this informed the decision to present the students with problems to solve, or digital media to create, involving multiple representations of the part-whole concept with a variety of referent units and with both countable sets and continuous quantities (length and area — including various regions and numbers of regions: circles, squares, triangles and irregular shapes).

**Fractions as ratios**

A ratio is 'an ordered pair that conveys the relative sizes of two quantities' and as such a part-whole fraction is a ratio (Lamon, 2012, p. 31) comparing the size of the part to the whole (however, although not discussed further here, part-part ratios can also be expressed as a fraction). In this way, a fraction as a ratio is a comparative index (Carraher, 1996; Charalambous & Pitta-Pantazi, 2007).

Mastery of ratios and proportions concepts is important for the study and comprehension of statistics, sampling, probability (Lamon, 2012) and geometry, scaling and mapping, as well as in recipes, art, graphic art, dilutions and stoichiometry (in chemistry, the relative proportions of amounts of substances in reactions reducible to whole numbers). Rates are ratios, but the two quantities, related by division, are different measures (Lamon, 2012). For example, speed is a rate of distance travelled divided by time taken to move that distance. Gradients are rates showing a comparative index of vertical gain compared to horizontal gain, that is, amount of rise per run.

As seen in Figure 2.1, and supporting the model posited by Behr et al. (1983), Charalambous and Pitta-Pantazi (2007) found using SEM that equivalence and ratios constructs are robustly associated. So, to compare the relative sizes of two quantities, an understanding of equivalence is central, and understanding ratios helps with the understanding of equivalence.

Multiplicative thinking is a ‘big idea’ in mathematics education which encompasses the ability to be able to see, interpret, work with, represent and solve problems involving multiplication and division including those found in fractions and proportions (Hilton, Hilton, Dole, & Goos, 2013; Hurst & Hurrell, 2016; Siemon, 2013). A proportion is a comparison of two ratios and so proportional reasoning comes under the umbrella of multiplicative thinking. Proportions can be direct or indirect (or inverse), the latter meaning that as one variable increases, the other decreases. An idea which links all fractions concepts is that of indirect or inverse proportions (Lamon, 2012), that is, when depicted symbolically, the greater the denominator, the smaller the fraction size.

I chose these proportional concepts for the students in this study to explore in relation to gradients and speed.

### Fractions as measures

‘Rational numbers are measures or points on a number line’ (Kieren, 1976, p. 103). It appears that within the fractions concept of measure are two inter-related main sub-concepts: one as fractions as numbers with a value and the other involving fractions as measures or intervals (see Charalambous & Pitta-Pantazi, 2007; Lamon, 2012). Seeing fractions as numbers with a value is demonstrated by placing and comparing them in magnitude on a number line (Kieren, 1976; Lamon, 2012). Seeing fractions as measures is concerned with the numeric distance between points of quantities and involves a ‘measure assigned to some interval… [such that] a unit fraction is defined (i.e., 1/a) and used repeatedly to determine a distance from a preset starting point’ (Charalambous & Pitta-Pantazi, 2007, p. 299).

Measure theory is important in calculus. In primary and lower secondary mathematics education, this concept of measure is notably used in the classroom with number lines. However

Charalambous and Pitta-Pantazi (2007) found evidence that students working with fractions on number lines was more aligned with the concept of equivalence than with other sub-tenets of measure (like the density property of rational numbers) purportedly because to compare fractions and place or interpret them on a number line requires a fluent knowledge of equivalent fractions.

As Clarke and Roche (2009) explain, it is the act of correctly understanding fractions' magnitude and comparing numbers on a number line which demonstrates students' comprehension of fractions. Subsequent work by Siegler et al. (2011), Booth and Newton (2012) and Torbeyns et al. (2014) have underscored this further. It even appears from Torbeyns et al. (2014) that a student's ability to place and compare fractions correctly on a number line, regardless of which of the three countries the research was conducted in and of the student's other mathematical abilities, predicts performance in latter years' mathematics.

These ideas and concepts informed my decision to invite students in this study to explore the concept of measure by asking them to create an activity involving comparing pairs of fractions for magnitude and to create an animation showing fractions on a number line.

**Equivalence**

Equivalence is derived from the Latin for 'equal value'. According to Wong (2010), equivalence is often taught for procedural efficiency rather than for conceptual understanding. Before numeric conversions are attempted, ideally students would have had plenty of practice representing fractions, decimal and percentages (e.g., Bando Irvin, 1994; Spangler, 2011) using manipulatives and illustrations (Caswell, 2007; Loong, 2014; Shin & Bryant, 2015) and rich open tasks (Sullivan, Clarke, & Clarke, 2009) which support the concept of equivalence as central to these conversions. Older students who are still struggling with the concepts could still benefit from using manipulatives (McNeil & Fyfe, 2012; Shin & Bryant, 2015), but might not be open to using concrete materials if doing so is not part of their classroom culture (Turpen & Finkelstein, 2010).

Equivalence is integral to understanding ratios, addition of unlike fractions, comparing the magnitude of fractions and placing and interpreting fractions on a number line (Charalambous &

Pitta-Pantazi, 2007). Understanding equivalence helps develop proportional thinking and multiplicative thinking (Hilton et al., 2013; Lamon, 2012; Siegler et al., 2011; Siemon, 2013). I used this information in this study when inviting students to create videos showing the link between concrete and symbolic (or numeric) representations of equivalence.

**Fractions as operators**

As operators, multiplication with fractions with a value less than one diminishes quantities (e.g., $\frac{1}{4} \times 12 = 3$; $\frac{1}{4} \times \frac{1}{4} = \frac{1}{16}$) and conversely fractions with a value greater than one expands quantities (e.g. $\frac{5}{4} \times 12 = 15$). Lack of experience with fractions outside of the part-whole concept can lead to students thinking fractions must always be less than one and lack of experience with multiplying improper fractions (‘top heavy’ fractions with a value equal to or greater than one) may lead to the common misconception that multiplication with fractions always makes the product smaller (Clarke, Roche, & Mitchell, 2011; Johanning & Mamer, 2014). Therefore, middle years students need to have plenty of experience in using fractions as operators with values not only less than, but equal to and greater than one.

**Fractions as quotients**

As quotients, fractions are the answer of a division (e.g., $3 \div 12 = \frac{3}{12} = \frac{1}{4}$). Students encounter this meaning of fractions especially in learning algebra; however, often students are less able to work fluently with these terms (Peck & Matassa, 2016) because they have not encountered and worked with them sufficiently in the middle years. It is within this concept that conversions are explored between decimal fractions (decimals), percentages and fractions, in that, each is or can be a quotient expressed in a different way.

There are complex steps which lead to the knowledge that terms related in division can be fractions and vice versa, that is, $a \div b \leftrightarrow \frac{a}{b}$ (see Empson, Junk, Dominguez, & Turner, 2006). Considering it is procedurally easy using a calculator to convert $a \div b$ to a decimal fraction, it is possible that the relationship between division and fractions might be lost and needs to be highlighted (see Clarke, 2006). The connections to the concepts of partitioning (division by sharing), quotition (division by repeated subtraction or division by known lumps or jumps) and fractions might have been bypassed in some students' education.

**Fractions concepts for an e-learning module**

From the study by Charalambous and Pitta-Pantazi (2007), it appears that the original assertion by Kieren (1976) that the part-whole concept of fractions is central to understanding fractions was supported, so for this study, any part-whole related misconceptions, including whole number bias, or yet to be mastered ideas, like working fluidly with improper fractions and non-circular representations of fractions, seemed to be a logical starting point with the students working to create the e-learning module.

The next concepts I considered the students might work on in their e-learning module were ratios, equivalence and measure. Charalambous and Pitta-Pantazi (2007) found that fluency with ratios concepts is associated with students' learning and construction of equivalence which in turn had an impact their ability to interpret and work with fractions on number lines. Comparing fractions magnitudes and working with fractions on number lines appears to be predictive of students' future success in school mathematics (Torbeyns et al., 2014).

In this study, a pedagogical aim was to give the students the opportunity to start with an overview of fractions concepts and misconceptions. Next, when working to create student-generated digital media for the e-learning module on fractions, the plan was for students to extend the potentially more familiar fractions concept of part-whole to the context of non-circular representations, and where possible, create opportunities for students to work with improper fractions. Then it was proposed that the students would work on creating digital media on the fractions sub-constructs of ratio (including rates like speed and gradients), of equivalence and of measure (by interpreting of fractions' magnitude on number lines) while making explicit connections between these concepts. An idea which links all fractions concepts is that the greater the denominator, the smaller the fraction value, that is, inverse proportional thinking. It was proposed that creating digital media for their e-learning module on fractions would foster these early adolescent students' engagement in mathematics.

**2.4 Concluding this Chapter**

In this study, I explore the level of engagement in activities of a class of Year 8 students while they create and select digital media and other elements for an e-learning module in fractions.

In this chapter, I considered the pedagogical approach, including the creative elements, of lower secondary students creating digital media in mathematics and why it might be engaging for them. When planning this study, I wanted to investigate engagement levels while early adolescent students worked on creating and selecting digital media on a mathematics topic which would, ostensibly, be of value to the students and their teacher: fractions concepts. I anticipated that the students would first need to understand the complexity of fractions concepts and then build upon what they might be likely to be familiar with (the part-whole concept of fractions and equivalence). The next planned step was to help students relate these foundations to age-appropriate concepts (ratios, including speed and gradients) and to an overarching connection which links all fractions concepts, inverse proportions. Although some care was taken to plan this intervention, as described in the three findings and discussion chapters, Chapters 6, 7 and 8, this approach and the assumptions driving it brought with it unexpected consequences.

In the next chapter, Chapter 3: Influences on Engagement, I discuss a broad range of factors which have been found to affect learning engagement and I provide more detail on those aspects which have special relevance to this study: (a) affect, including emotions (especially enjoyment and boredom), prior experiences and affect regarding student achievement; (b) psychosocial factors; (c) researched influences on and traits of early adolescents;  (d) teacher effects and pedagogical choices; and (d) physical factors affecting learning engagement.

# Chapter 3: Influences on Engagement

Skinner and Pitzer (2012) have stated two researched reasons why engagement has caught attention of educationalists: firstly, engagement can be influenced in schools, in the classroom, by teachers and by the students themselves; and secondly, improvements in engagement improve students' learning, academic achievement scores, retention in school and graduation rates (Al-Hendawi, 2012; Christensen, Knezek, & Tyler-Wood, 2015; Christenson, Reschly, & Wylie, 2012; Fredricks, Blumenfeld, & Paris, 2004). This literature review is delimited to factors which can be conceivably influenced within the classroom. As such, parental, socio-economic and gender issues are not discussed.

There appears to have been a shift in research focus in engagement in the last two decades in that much of the early research, and some current work, was conducted to alleviate 'persistent educational problems such as low achievement, high dropout rates, and high rates of student boredom and alienation'(Fredricks et al., 2016, p. 1). However, a review of engagement literature by Taylor and Parsons (2011) has shown that increasingly researchers seem to want to understand how to engage all students positively. It appears that engagement is integral to learning.

A range of influences, both positive and negative, have been found to impact engagement and it is proposed that these factors would feasibly impact on the students of this study when presented with a learning activity. I felt that it was important to explore and document the influences on engagement to not only help interpret the findings, but to better understand the construct itself through that which affects it. Furthermore, I needed to explore the context and timeframe in which factors might influence activity level engagement of this study and those which pertain especially to the mathematics classroom of early adolescents.

The importance of understanding engagement is clear. As stated by Sinatra et al. (2015, p. 1), 'Engagement could be described as the holy grail of education'. The impetus for this study was to provide insights into widespread and long-held trend of early adolescents disengaging from studying mathematics (Attard, 2013; Martin et al., 2012), but also there is the impetus to understand the construct itself, both what influences it, as discussed in this chapter, and how to define it, as discussed in the next chapter,  Chapter 4: Defining Engagement and the Theoretical Framework.

## 3.1 Signposting this Chapter

In this chapter, I discuss the existing individual receptivity, psychoeducational, peer influences, pedagogical choices and physical environment which may influence engagement of early adolescent students both when a learning task is presented to them and throughout the learning and engagement process.

In section 3.2 The Affective Domain, after defining the affective domain and discussing the control value theory of achievement emotions (Pekrun, 2006), I discuss beliefs, values, attitudes and emotions in mathematics which have been reported to influence engagement. I also discuss anxiety, boredom and enjoyment and how achievement and students' prior experiences affect engagement.

In section 3.3 Psychoeducational and Social-Cognitive Factors, I draw on Martin's (2007a) Motivation and Engagement Wheel for a conceptualisation of adaptive and maladaptive psychoeducational factors influencing learning engagement and motivation at the activity level. I also discuss socially constructed approaches to learning and mindsets which affect engagement.

In section 3.4 Research on Early Adolescents' Engagement, I explore researched psychosocial factors of early adolescents and their reported or projected effects on engagement in lower secondary mathematics classes.

In section 3.5 Teacher Effects and Pedagogical Choices, I discuss the effect teachers have on student engagement. Then I explore researched engaging pedagogical approaches and those which John Hattie has analysed as effectively supporting learning achievement and which presumably support students' engagement.

In section 3.6 Physical Factors, I discuss the situational considerations, including fresh air, lighting and time of day which research supports as influential on student engagement or achievement.

## 3.2 The Affective Domain

Research in the study of affect in mathematics education has increased in the last two decades mainly in response to negative views about the subject (Grootenboer & Marshman, 2016) and a rising awareness that understanding the mechanisms of how mathematics is best learnt and taught has been insufficient in knowing how to engage students, and what affective factors influence students to learn mathematics, keep learning mathematics or turn away from it (Forgasz, 2006a; Hemmings, Grootenboer, & Kay, 2011; Martin et al., 2012). As well as exploring research which aimed to uncover how to mitigate disengagement, it has been useful to look at research on the conditions which elicit positive emotions in education (Frenzel, Goetz, Lüdtke, Pekrun, & Sutton, 2009; Goetz, Frenzel, Hall, & Pekrun, 2008) and in mathematics education in particular (Buff, 2014; Frenzel, Pekrun, & Goetz, 2007). This focus is in line with the review finding by Taylor and Parsons (2011) that there is a burgeoning trend to research the enhancement of positive engagement.

Reviewed by Hannula (2012), early research in the 1980s on affect in mathematics largely involved self-report surveys on mathematics anxiety and students' attitudes to mathematics. The seminal paper by McLeod (1992) reconceptualised the field by introducing a framework showing three major categories of affect — emotions, attitudes and beliefs — in order of increasing stability, duration, cognitive involvement and decreasing intensity. For McLeod, attitudes were thought to be formed by repeated experiences of emotions while beliefs were formed by socially mediated personal or observed experiences and culture.

### What is affect?

Comparing emotion and affect, ‘affect’ is defined in the APA online dictionary of psychology (n.d.) as including emotion, feelings and mood, and as such is a broader term than emotion. For Grootenboer and Marshman (2016), following on from McLeod (1992), there are more affect categories than those mentioned in the APA dictionary. These distinct but overlapping categories are distinguishable by four factors: (a) the length of time that they are held (stability); (b) degree of cognition involved; (c) how labile they are; and (d) their intensity. Presented in descending order of the four determining factors, Grootenboer and Marshman’s affect categories are the following: beliefs, values, attitudes, moods and feelings or emotions.

In this study, the research and data collection emphases are on students’ responses to activities and as such focusses on the shorter-term affective state: emotions (expressed or observable feelings, see below). However, in this chapter, I also consider the longer-term affective influences on engagement — attitudes, values and beliefs.

### Beliefs and values

Although there are multiple, overlapping definitions of beliefs, values and attitudes (the longer-term affective states), Grootenboer and Marshman (2016) seem to have found some congruency and alignment. As reviewed by Grootenboer and Marshman, it would appear that beliefs are personal, subjective understandings (Philipp, 2007; Rokeach, 1968) of what is true in the world (Richardson, 1996) that range from fairly immutable core beliefs based on an individual’s own experiences to those that are more amenable to change derived from observing or being influenced by others’ experiences (Green, 1971). Beliefs are organised into like sets (Rokeach, 1968).

Values also seem to be long-held affective entities arranged into related clusters but differ from beliefs in two main dimensions. Values appear to be deeply held subjective platforms of what is good or worthwhile and seem more likely to evoke action than beliefs (Philipp, 2007).

If a student values mathematics as a discipline, he/she is more likely to persist and therefore succeed in mathematics studies (Martin et al., 2012; Martin et al., 2015). Martin et al. (2012) found that if middle years students ($n$ = 1,601) valued mathematics it was a positive predictor of future intent in mathematics and it was negatively correlated with disengagement from mathematics.

**Self-efficacy (self-belief) in and valuing of mathematics education**

According to the APA dictionary of psychology (n.d.), ‘self-efficacy’ is ‘an individual’s subjective perception of his or her capability to perform in a given setting or to attain desired results, proposed by Albert Bandura as a primary determinant of emotional and motivational states and behavioral change’. Bandura and Schunk (1981) state that ‘self-efficacy is concerned with judgments about how well one can organize and execute courses of action required to deal with prospective situations containing many ambiguous, unpredictable, and often stressful elements’ (p. 587). In other words, it appears self-efficacy is a person’s belief in their ability to achieve challenging goals and as such would seem to be crucial in determining engagement.

Bandura (1977) contended that when faced with an obstacle (a threat, perceived threat or a challenging problem), an individual would choose between coping or defensive behaviour depending on their level of self-efficacy. Self-efficacy for a particular area of human endeavour increases most powerfully when an individual experiences mastery through effective performance. For example, Bandura and Schunk (1981) found that primary school students who had disengaged from mathematics improved significantly and strongly in their self-efficacy and mathematics performance when they were given suggestions of a proximal goal to achieve (complete one set of self-instructional, progressively-difficult subtraction problems in each session) compared with a distal goal (complete seven sets of the same problems by the end of seven sessions) or no suggestions of any goals (control group) with the same instructional materials. The students in the first group were able to experience success and rising capability, and therefore mastery, through their own endeavours. The teachers of these students reported a significant improvement in these students' attitude to, engagement and performance in mathematics (the researchers offered and delivered the 'distal' and control group the same conditions after the experiment).

Many scholars have reported that middle years students' self-efficacy (Bandura, 1977; Bandura & Schunk, 1981) in mathematics importantly affects their mathematics engagement or achievement (Holm, Hannula, & Björn, 2017; Martin et al., 2015; Middleton, 2013; Schweinle, Meyer, & Turner, 2006; Winheller, Hattie, & Brown, 2013). McPhan, Morony, Pegg, Cooksey, and Lynch (2008) observed that lower self-efficacy and valuing of mathematics reduced the likelihood of students persevering with higher level mathematics, and Brown, Brown, and Bibby (2008) discovered the same factors affect mathematics engagement. With early adolescents, Martin et al. (2015) found that self-efficacy was protective over the often-adverse period of school transition and predicted gains in mathematics engagement and in planning, task management, persistence, lower self-handicapping, lower disengagement, class participation, effort, homework completion and enjoyment in mathematics.

**Changing beliefs**

As explained by Grootenboer and Marshman (2016), given that beliefs are thought to be formed through an individual's own or vicarious experiences, it would seem negative beliefs about mathematics could simply be changed by giving students direct positive mathematical experiences, but it appears more complex than that. As they note, 'For an individual to change their beliefs, they need to desert premises that they hold to be true, and often this is difficult and challenging, particularly the more central and primary the beliefs' (p. 17). Furthermore, the individual would need to reflect upon the episodes which helped formulate the unhelpful belief, deconstruct and examine them, and be willing to reconstruct a new belief with new evidence and experiences (Grootenboer & Marshman, 2016). Otherwise, it appears likely the individual would retain the original belief, regardless of conflicting evidence, and process information with a confirmation bias (Klayman, 1995). However, cognitive behaviour therapy (Beck, 1976) has been shown to be very effective in altering maladaptive beliefs in the field of psychotherapy and is discussed briefly below in a sub-section of 3.3 Psychoeducational and Social-Cognitive Factors.

**Difference between shorter-term valuing and long-term values**

As will be discussed in more detail in Chapter 4: Defining Engagement and the Theoretical Framework, expectancy value theory (Eccles et al., 1983; Wigfield & Eccles, 2000) holds that when valuing is at the learning task level it concerns weighing the value or worth of an external activity depending on the expectancy of success and the costs and benefits of engaging. Values, on the other hand, are internalised, deeply held principles. As such, the valuing of an activity is much shorter lived, less likely to be deeply held and is not necessarily congruent with deeply held values. For example, a student could value mathematics as mesmerizingly challenging, worthwhile and crucial for success (a longer term value) but not value an activity within a mathematics lesson (shorter term) because, perhaps, it is not challenging enough or he/she perceives that task as irrelevant — or conversely a student could like an activity but not value mathematics in general.

**Attitudes**

Attitudes are reportedly less durable than values and beliefs (Grootenboer & Marshman, 2016; McLeod, 1992) and appear more likely to be verbalised or otherwise expressed (Philipp, 2007). Grootenboer and Marshman (2016) conclude from McLeod (1992) and Philipp (2007) that attitudes are 'learned responses… that develop from several similar and repeated emotive responses to an event or object… and they are either positive or negative' (p. 19). This implies that negative attitudes towards mathematics have developed through repeated unpleasant exposures. Unfortunately, it seems people obtain negative attitudes to mathematics at school. As stated by Grootenboer and Marshman (2016):

> Indeed, it seems to us that it is a somewhat ironic and sad situation if students are learning debilitating beliefs about mathematics, and developing poor attitudes and self-confidence in mathematical engagement, in the very place you would hope students would grow to appreciate and understand the subject (p. 2).

### Effect of prior achievement on engagement

Martin et al. (2015) found that individual achievement in mathematics predicted engagement in the subject over the transition from primary school to secondary as well as individual achievement positively affecting homework completion, enjoyment and lower levels of self-handicapping. Similarly, if the class average achievement in mathematics was low, the researchers found this was associated with disengagement, lower class participation, lower effort and lower homework completion. Adding to the complexity, it has been known for a few decades with the ‘big fish little pond effect’(Marsh, 1987) that attainment alone is not enough to predict attitudes and beliefs to a subject because higher achievers schooled with lower achievers tend to have higher academic self-concept than those with the same achievement level who school with those of similar ability. From Martin and colleague’s research, it would appear that academic self-concept predicts engagement.

### Conceptualising emotions

Emotions are, naturally, integral to human life, so it seems to be surprisingly difficult to define what they are. Nonetheless, the APA online dictionary of psychology (n.d.) defines emotions in the following way:

> [Emotions are] a complex reaction pattern, involving experiential, behavioral, and physiological elements, by which an individual attempts to deal with a personally significant matter or event. The specific quality of the emotion (e.g., fear, shame) is determined by the specific significance of the event. For example, if the significance involves threat, fear is likely to be generated; if the significance involves disapproval from another, shame is likely to be generated. Emotion typically involves feeling but differs from feeling in having an overt or implicit engagement with the world.

In education, Pekrun (2006) has categorised academic or achievement emotions into two classes: outcome emotions and activity-related emotions using the  control value theory of achievement emotions.

### The control value theory of achievement emotions

The control-value theory of achievement emotions (Pekrun, 2006), CVTAE, characterises emotions along two main dimensions: (a) whether students perceive they can do the activity (that is, feel in *control*) or not; and (b) whether students want to do the activity (that is, *value* the activity) or not. Pekrun proposed that emotions involved in learning are either activity-related, that is, relate to success or failure (e.g., satisfaction, pride, relief, shame, disappointment) or in anticipation of success or failure (e.g., anxiety) or are evoked during engagement (e.g., interest, enjoyment, boredom, frustration). The latter class of emotions were thought to be most pertinent to this study and expression of them by the participants was used to help gauge engagement, or lack thereof, in an activity.

The control and value dimensions also produce an array of emotions based on two further dualities: positivity or negativity and whether activating or deactivating (Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017). So, in relation to emotions found to be important in learning, Pekrun and colleagues (2017) have categorised the following: (a) enjoyment and pride as positive activating emotions; (b) relaxation and relief as positive deactivating emotions; (c) frustration, anxiety and shame as negative activating emotions; and (d) boredom and hopelessness as negative deactivating emotions.

Lastly, positive emotions both facilitate learning and are associated with the use of effective strategies, and negative emotions both inhibit learning and are associated with maladaptive strategies (Pekrun et al., 2017). So, the key emotion expressed during learning engagement (which is positive, activating and facilitates learning) is enjoyment (and that which seems to be associated with it, interest). The polar opposite, the deactivating emotion expressed during learning and which inhibits learning, is boredom.

In the remainder of this section, three emotions which relate to mathematics education or learning activity engagement are discussed: anxiety, enjoyment and boredom. Anxiety has been well researched in mathematics education (e.g., Attard et al., 2016; Grootenboer & Marshman, 2016; Krinzinger et al., 2009; Ma & Xu, 2004). However, as discussed below, anxiety may not be a good marker of learning activity disaffection. In contrast, enjoyment appears to be strongly relevant to activity engagement. Boredom also appears to be pertinent to learning activity engagement, or rather, disaffection, but, as discussed below, is complex and there appear to be multiple causes and many reasons why a student might state that he/she is bored (Pekrun, Goetz, Daniels, Stupnisky, & Perry, 2010; Tze, Daniels, & Klassen, 2016; Vogel-Walcutt, Fiorella, Carper, & Schatz, 2012).

**Characterising mathematics anxiety**

In this section I explain why mathematics anxiety, although an important affect in mathematics education may not be useful as a marker of learning activity disaffection, but rather seems to be related to achievement or perceived potential failure. Perhaps counter-intuitively, mathematics anxiety, an uncomfortable feeling of stress or foreboding associated with mathematics, although strongly associated with poor student outcomes in mathematics (see for an extensive discussion Grootenboer & Marshman, 2016), is likely not the cause of them (Krinzinger et al., 2009; Ma & Xu, 2004; Sherman & Wither, 2003). Rather, it is likely to be the other way around, or that a third causative agent is at work — possibly self-efficacy (perceived self-belief in ability) in mathematics (Berger & Karabenick, 2011).

In a US longitudinal panel analysis of junior and high school students ($n$ = 3,116), Ma and Xu (2004) found evidence that *poor achievement* in mathematics caused mathematics anxiety. Sherman and Wither (2003) followed the outcomes and reported emotions of 56 primary students transitioning into secondary college in Adelaide, and could conclude mathematics anxiety did *not* cause poor mathematics outcomes, but could not rule out the reciprocal effect or that a third factor was at play. Krinzinger et al. (2009) in Germany found that, for young primary school students ($n$ = 140), mathematics anxiety and mathematics achievement were not causally related in either direction, but that student self-evaluation in mathematics (presumably equivalent to self-efficacy in mathematics) was affected by both mathematics achievement and mathematics anxiety. Ahmed, Minnaert, Kuyper, and van der Werf (2012) in The Netherlands found a degree of reciprocity in the relationship between the causal effects of the mathematics anxiety and mathematics self-efficacy, but they established that self-concept in mathematics was twice as potent in affecting mathematics anxiety than the other way around.

In regards to engagement or rather disengagement, Martin et al. (2012) found a slight, but significant, positive correlation between mathematics anxiety and disengagement in mathematics in middle years students, but the effect was small compared to that of the negative correlation between enjoyment and disengagement in mathematics. Please refer to Figure 3.1 showing that, out of enjoyment, anxiety, valuing and self-efficacy, enjoyment had both the strongest protective correlation effect against disengagement and the strongest predictive effect for students' future intent with mathematics.

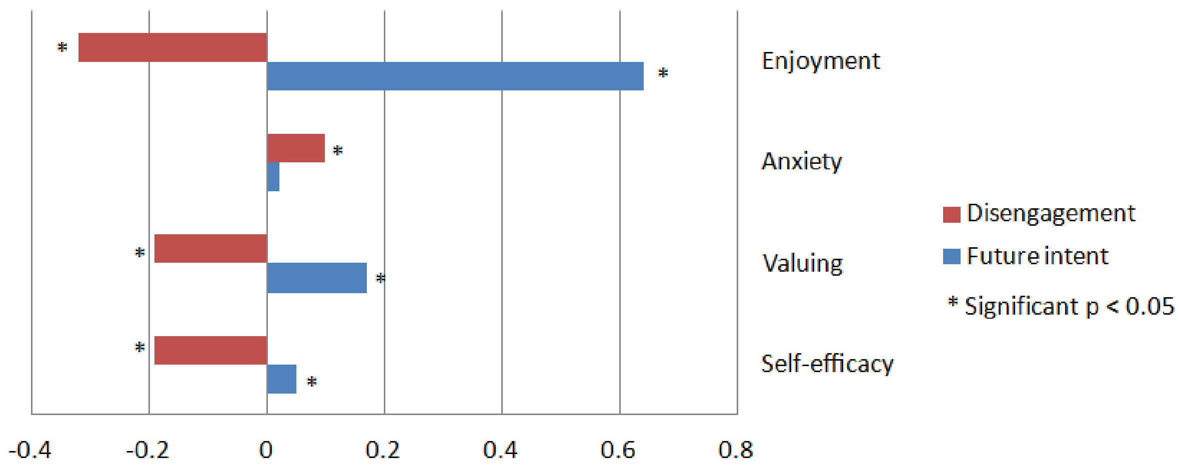



*Figure 3.1*. Correlation between predictive factors and mathematics disengagement and future intent in middle school students as found by Martin et al. (2012). Adapted from 'Switching on and switching off in mathematics: An ecological study of future intent and disengagement among middle school students,' by A. J. Martin, J. Anderson, J. Bobis, J. Way and R. Vellar, 2012, *Journal of Educational Psychology, 104*(1), 1-18. Copyright 2012 by American Psychological Association. Adapted with permission.

It appears that expressed, observed or self-reported anxiety would be not be a reliable indicator of a student's level of engagement or disengagement in mathematics. In contrast, enjoyment in mathematics appears to be a crucial emotion in studies of engagement and seems to have potential as an indicator of engagement.

**Characterising enjoyment in mathematics**

As noted above, enjoyment and other achievement-related emotions have been characterised by Pekrun et al. (2017) along two dimensions: pleasantness and unpleasantness (or positivity and negativity); and whether they are activating or deactivating. For these researchers, enjoyment is viewed as a pleasant and activating emotion.

Despite being an emotion that strongly protects against disengagement (Martin et al., 2012), enjoyment in mathematics appears not to be as widely researched as mathematics anxiety. To illustrate, a recent search I conducted in the Education Resources Information Center (ERIC) database using the main subject heading search terms 'mathematics education' or 'mathematics' and 'enjoyment' produced 13 publication results. The same search swapping 'anxiety' for 'enjoyment' returned 245 results.

From the literature, it appears that researchers are interested in looking at enjoyment and other emotions both in relation to academic achievement (Frenzel et al., 2007; Pekrun, 2006) and to benefits in well-being (Fredrickson, 2001). For example, Fredrickson (2001, p. 218) is of the view that 'positive emotions are worth cultivating, not just as end states in themselves but also as means to achieving psychological growth and improved well-being over time'.

In terms of mathematics engagement, Martin et al. (2012) found in a study of Australian lower secondary students that those who enjoyed mathematics were less likely to be disengaged from the subject and were more likely to include mathematics in future study choices. In that study (and as depicted in the previously presented Figure 3.1), the effect sizes for enjoyment negatively correlating with disengagement and positively correlating with future study choices in mathematics were found to be greater than those for mathematics anxiety. The findings of Martin et al. (2012), that student enjoyment of mathematics was correlated with decreased disengagement and increased likelihood of students including mathematics in their future mathematics, were also highlighted by earlier research (Brown et al., 2008; McPhan et al., 2008).

In terms of learning activity engagement, Skinner and Pitzer (2012, p. 27) summarised that students report experiencing more enjoyment (and 'persistence, achievement and learning') when their need for autonomy is supported (Miserandino, 1996; Stroet et al., 2013). They further suggest that students' intrinsic motivation can be maintained by 'offering challenging and fun learning activities' (p.34). According to Eccles and Wang (2012, p. 143), students subjectively evaluate learning tasks according to their 'beliefs about how enjoyable the task will be' as well as how useful it will be in satisfying their personal needs and goals, fitting in with their picture of their identities and the costs and benefits in expending effort.

**Characterising boredom**

Boredom has been defined as 'a state of weariness or ennui resulting from a lack of engagement with stimuli in the environment' (American Psychological Association, 2018) and as such, boredom experienced in achievement settings has been associated with poorer academic outcomes (Pekrun et al., 2010). Unfortunately, boredom is a prevalent emotion in schools (Goetz et al., 2014; Macklem, 2015; Pekrun et al., 2010). In a US study ($n$ = 81,499), Yazzie-Mintz (2007) found that 50% of the canvassed secondary school students reported being bored every day and only 2% reported never being bored. Goetz et al. (2014) found evidence of a range of boredom types from (surprisingly) mildly pleasant to strongly unpleasant with low to high arousal levels. The high arousal type appears to challenge the APA definition and that by others (Vogel-Walcutt et al., 2012).

In his ethnography on boredom with Year 7 and 8 students, Breidenstein (2007) noted that boredom is often associated with 'waiting, passing the time away (or 'killing time')' (p. 94) and Macklem (2015) reviewed that 'the individual who is bored has difficulty paying attention, difficulty concentrating, and effort is required to maintain focus on (and not become distracted from) what is going on in the environment' (p. 1-2). So, it appears the negative experience of boredom has a temporal component whereby the bored person has a heightened awareness of time passing and difficulty in focussing (perhaps contrasting neatly with the concept of flow [Csikszentmihalyi, 2014] characterised by heightened focus and obliviousness of time passing). Breidenstein (2007) also noticed an implicit agreement between students and the teacher who expects and allows a certain amount of boredom in the classroom as long as the set assignments are done. He also noticed a taboo that boredom should not be expressed overtly.

***Contributing factors.*** As reviewed by Vogel-Walcutt et al. (2012), several factors affecting boredom have been identified: (a) perceived meaninglessness of a task (Kinchin & O'Sullivan, 2003); (b) unclear task (Azevedo & Strain, 2011; Mayer, 2004); (c) perceived low control for students (Azevedo & Strain, 2011; Kinchin & O'Sullivan, 2003); and (d) inappropriate difficulty level (Azevedo & Strain, 2011). Yazzie-Mintz (2007) found US secondary school students were bored due to perceived problems with the material: not interesting (75%); irrelevant (39%); insufficiently challenging (32%); or too challenging (27%); or having no interaction with the teacher (31%).

***Boredom proneness.*** Vogel-Walcutt and colleagues (2012) found that 'state' boredom, which can be mitigated in the classroom, is different to 'trait' boredom (elsewhere referred to as boredom proneness, e.g., Farmer and Sundberg, 1986) whereby the subject is disposed to routinely experiencing multiple contexts as boring. It is not yet clear whether this apparent within-individual boredom proneness might be due to low physiological stimulation which needs to be compensated from without (see Murray-Close, 2013) or general, existential lack of meaningfulness (see MacDonald & Holland, 2002; Macklem, 2015) or both or some other reasons. Regardless, the difference between state boredom and boredom proneness was helpful in this study in distinguishing between students who might say everything is boring and those who would discriminate among activities.

***Boredom in mathematics.*** In mathematics education, it appears that boredom might be linked to self-efficacy. Ahmed, van der Werf, Kuyper, and Minnaert (2013) found that as the year progressed for Year 7 mathematics students in The Netherlands, their mathematics self-efficacy and achievement decreased, along with their pride and enjoyment in the subject, and their reports of boredom increased. As summarised by Holm et al. (2017), boredom can be experienced by students if they are challenged too much or not enough, or think the activity is pointless. They found with Finnish adolescents in mathematics that there was no difference in questionnaire-derived boredom levels across three achievement level groups (students who experience mathematics difficulty; low-achieving students; and typically achieving students). That is, it appears that these students experienced the same level of boredom in their mathematics classes despite the potentially different reasons. This perhaps hints of different types of boredom.

***Five sub-types of boredom.*** Using real-time, experience sampling with German secondary school ($n$ = 80) and university students ($n$ = 63), Goetz et al. (2014) found empirical evidence supporting five types of boredom characterised along two orthogonal, Likert-scale-reported constructs, valence (positive to negative affect) and level of arousal:

(a) Indifferent boredom

  a. Very low arousal; slightly positive valence
  b. Characterised by indifference to the surrounding context and a ‘relaxing and cheerful fatigue’ (p.403);

(b) Calibrating boredom

  a. Low arousal; slightly negative valence
  b. Characterised by aimless boredom and non-agentic openness to changing to a more stimulating condition;

(c) Searching boredom

  a. Mid-level arousal; mid-level negativity

   b. Characterised by agitated restlessness and actively seeking ways to reduce boredom;

(d) Reactant boredom

   a. Highest arousal; strong negative valence

   b. Characterised by the need to escape the 'boredom-inducing situation and avoid those responsible for this situation (e.g., teachers)' (p. 403);

(e) Apathetic boredom

   a. Very low arousal; very strong negative valence

   b. Characterised by withdrawal; highest prevalence — noted in 36% of responses

Please refer to Figure 3.2 to see a graphic depiction of the valence and arousal-levels of these sub-types of boredom. Goetz et al. (2014) found that indifferent and calibrating boredom was most likely in non-academic contexts (e.g., shopping) and the other types were prevalent in academic settings. Possibly Vogel-Walcutt and colleagues (2012) reviewed studies regarding the most prevalent sub-type in academic settings. In this current study, the instruments did not enable discernment between boredom sub-types but nonetheless, on occasions, observations could be made which seemed to align with these categorisations.

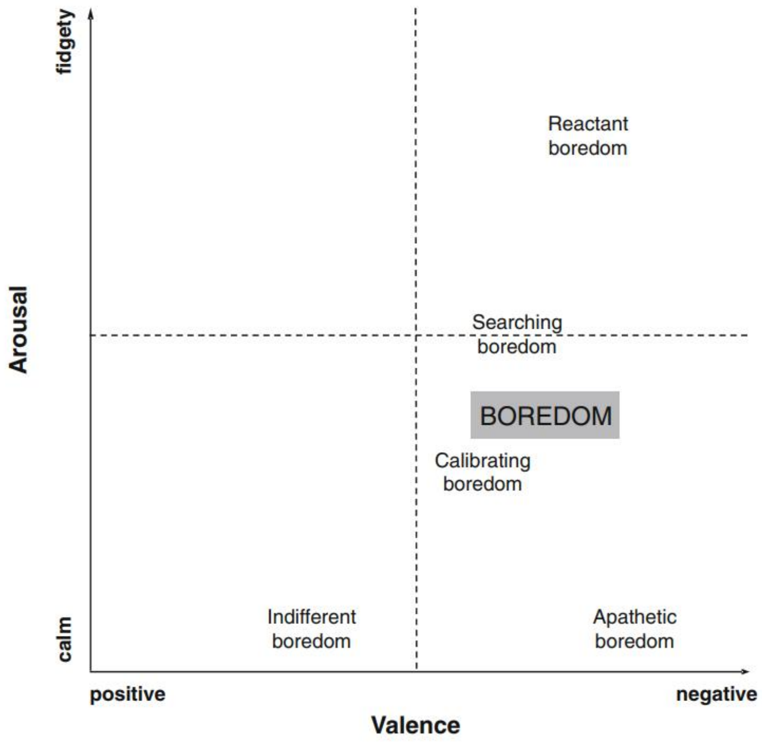



*Figure 3.2*. Five boredom types and mean boredom along valence and arousal dimensions. From 'Types of boredom: An experience sampling approach' by T. Goetz, A. C. Frenzel, N. C. Hall, U. E. Nett, R. Pekrun and A. A. Lipnevich, 2014, *Motivation and Emotion, 38*, p. 415. Copyright by Springer Nature. Reprinted with permission.

***Complexity.*** Despite complexity regarding the experience and expression of boredom in lower secondary mathematics classrooms, it appears from Vogel-Walcutt and colleagues (2012), that boredom can apply to a specific activity as a shorter-term state disaffection, and as such it seems boredom can be framed as an indicator of a situational problem which can be identified and addressed. This was deemed useful in this study for helping to identify activities which the students did not like. However, also shown by Vogel-Walcutt et al. (2012), self-reporting of boredom may not be accurate as individuals can conflate one emotion with another, for example, stating they are bored when they are actually confused or tired. This would seem to indicate that multiple data sources are needed to ascertain boredom, but that nonetheless, boredom appears to be an indicator of disaffection and can be applied to a particular activity. Furthermore, the complexity of the experience and expression of boredom has implications for this study in deciphering if the students were any of, or a combination of, the following during an activity: bored as described by any of the five sub-types (Goetz et al., 2014); merely uninterested; tired; confused (Vogel-Walcutt et al., 2012); exhibiting boredom proneness (experiencing everything as boring; Farmer & Sundberg, 1986); disengaged (longer term withdrawal; Martin et al., 2012); influenced by something else (e.g., lowered self-efficacy in mathematics; Ahmed et al., 2013); or experiencing social pressures (e.g., peer influences — see section 3.4 Research on Early Adolescents' Engagement) for stating they were bored.

**Prior experiences**

Pekrun et al. (2017) found that prior experiences in the classroom which are positive and activating, that is, are enjoyable, set up for engagement in similar tasks. Similarly, but in the opposite direction, prior experiences in the classroom or experienced by individual students which are negative and deactivating, that is, boring, set up for students not engaging with similar tasks.

## 3.3 Psychoeducational and Social-Cognitive Factors

In this section, I refer to Martin's (2007a) Motivation and Engagement Wheel to discuss psychoeducational influences on engagement and motivation and social-cognitive factors, including learning approaches and mind set (growth or fixed), which affect learning engagement.

The Motivation and Engagement Wheel (Martin, 2007a) (referred to hereon as Martin's Wheel) is a multidimensional framework which has been validated along with its measuring instrument, the Motivation and Engagement Scale (Liem & Martin, 2012; Martin, 2007b) in education, work, sport, and music settings. It was designed for and has been used by practitioners (teachers and psychologists) to help students understand their own learning thoughts and behaviours, both adaptive and otherwise (Liem & Martin, 2012; Martin, 2007a, 2013). Martin's Wheel diagrammatically shows the connection between both adaptive and maladaptive affective-cognitive and behavioural factors which relate to motivation and engagement respectively.

### Martin's Wheel

Structurally, Martin's Wheel (2007) is split into diametrically opposed quadrants each with two or three factors: (a) adaptive affective-cognition — self-efficacy, valuing, and mastery orientation; (b) impeding /maladaptive affective-cognition — anxiety, failure avoidance, and uncertain control; (c) adaptive behaviour — planning, task management, and persistence; and (d) maladaptive behaviour — self-handicapping and disengagement. The basis of the dimensions and each of the constituent 11 factors has been extensively researched by multiple research teams (see below), and the framework itself has used by Plenty and Heubeck (2013) to gauge motivation and engagement of regional Australian students in mathematics compared to general academic studies. Referring to Figure 3.2, the simple graphic shows the relationships between the dimensions and the factors, as described by Martin (2007a), and is useful in this study explaining psychoeducational and social-cognitive factors and their polar opposites.

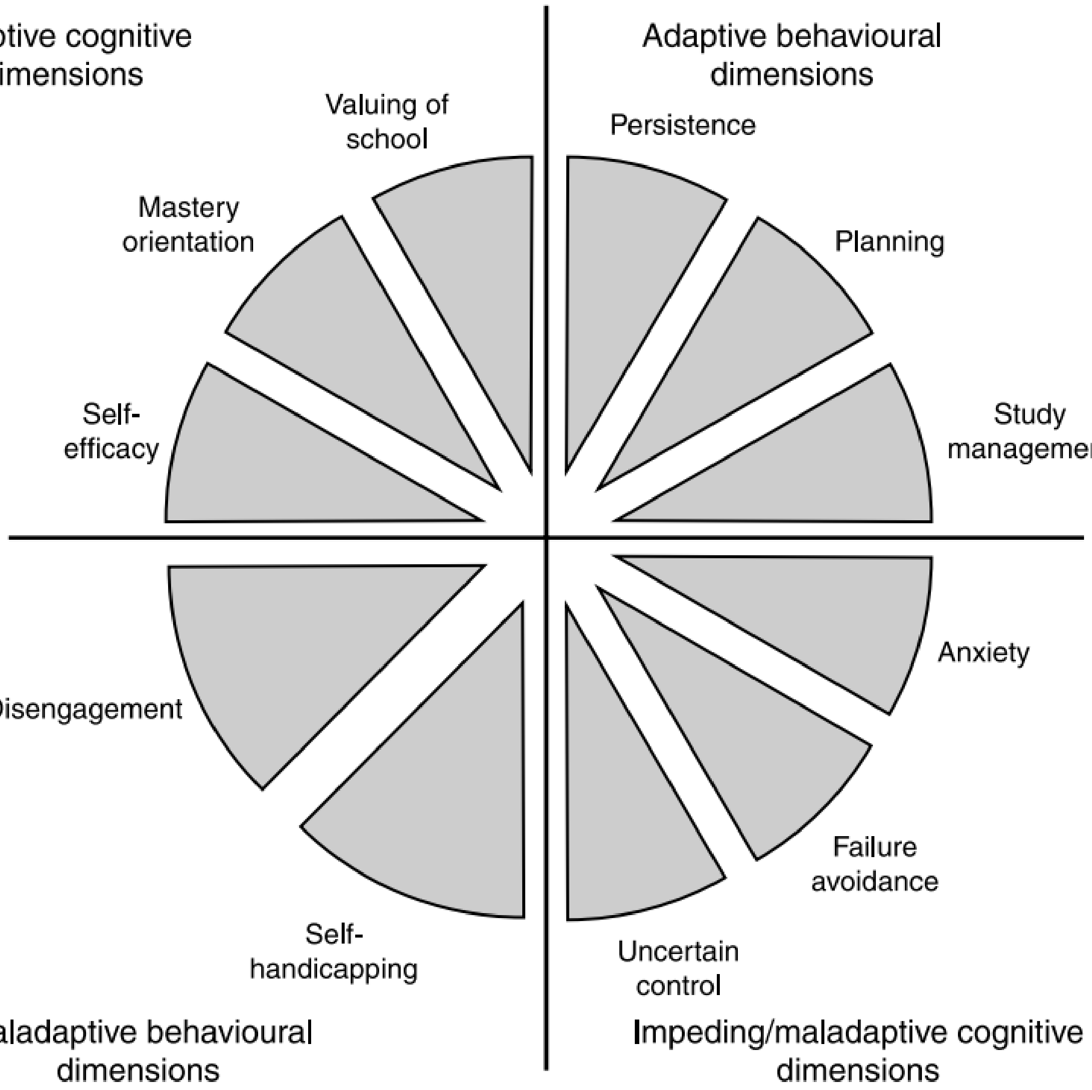



*Figure 3.3.* Martin's (2007a) Motivation and Engagement Wheel. From 'Examining a Multidimensional Model of Student Motivation and Engagement Using a Construct Validation Approach' by A. J. Martin, 2007a, *British Journal of Educational Psychology, 77*, p. 414. Copyright 2007 by The British Psychological Society. Reprinted with permission.

Martin's (2007a) Wheel draws from a wide range of research and theories in psychology and education. This includes (a) expectancy value theory (EVT) (Covington & Müeller, 2001; Eccles & Wigfield, 2002; Pintrich, 2000; Pintrich & De Groot, 1990; Wigfield & Eccles, 2000); (b) cognitive behavioural therapy approach (Beck, 1976, 1993) applied to education;(c) self-efficacy research (Bandura, 1991; Pajares, 1996); (d) self-determination theory (Deci & Ryan, 1985); (e) the motivational model of engagement (Connell & Wellborn, 1991; Miserandino, 1996); (f) anxiety research (Ashcraft & Kirk, 2001; Sherman & Wither, 2003); and (g) self-handicapping and other maladaptive engagement research (Covington & Müeller, 2001; Martin, Marsh, Williamson, & Debus, 2003).

In this discussion, I draw upon Martin's Wheel to illustrate and capture major adaptive and maladaptive orientations and practices which exemplify or have been found to influence school and mathematics engagement. I have assumed these factors, if pre-existing before the presentation of a learning activity, would thereby influence engagement of students at the learning activity level. Before discussing these influences, it seems worthwhile to note that different researchers appear to define and use important terms differently. In an attempt to navigate through differing uses of the word 'cognitive', in this study, I have reserved the stand-alone terms 'cognition' and 'cognitive' to refer to *mental processing* directed *towards achieving* a learning goal (e.g., understanding, categorising, analysing etc.) and use 'affective-cognitive' and 'affective cognition' to refer to affective factors (attitudinal, belief and valuing factors; see Grootenboer and Marshman, 2016) which involve *thinking about* learning.

In the following sub-sections, first I discuss pre-existing adaptive and positive affective-cognitive factors or practices from Martin's (2007a) Wheel which would seem to aid engagement once a learning activity is presented to students and then I discuss those factors from Martin's Wheel which would seem to impede engagement in learning activities.

**Adaptive, pro-engagement factors from Martin's Wheel**

Adaptive affective-cognitive factors, which align with positive motivation for learning according to Martin's (2007a) model, include self-efficacy, valuing and mastery orientation. The practices which would seem to set up for learning activity engagement are persistence, planning and task or study management. Self-efficacy and valuing have been described in section 3.2 under the heading 'Self-efficacy (self-belief) in and valuing of mathematics education', but here I discuss self-efficacy again in terms of cognitive behavioural therapy which Martin draws upon in his discussion.

***Cognitive behavioural therapy and self-efficacy.*** Martin (2007a) refers to cognitive behavioural therapy theory as useful in his conception of his Wheel. Cognitive behavioural therapy (CBT) theory holds that behaviours influence thoughts and attitudes, thoughts influence feelings, and in turn, feelings influence behaviour (Beck, 1976). A central tenet of Beck's CBT is that maladaptive mental states and behaviours stem from acquired maladaptive attitudes and beliefs (e.g., no one loves me; I am hopeless at maths; my body is ugly) which can lead to maladaptive behaviour (e.g., avoiding friends, avoiding learning opportunities, manifesting an eating disorder) and mental disorders (e.g., depression, anxiety disorder and panic disorder).

In order to affect change, small behavioural goals are posed and when achieved this confronts the dysfunctional attitude driving the behaviour. These manageable successes change the emotional response, reduce fear and if consistently applied, change the problematic attitude or belief. Small attainable goals are key to this widely used and effective treatment (Hofmann, Asnaani, Vonk, Sawyer, & Fang, 2012) such that the affected person experiences success and growing self-efficacy. It seems that Bandura and Schunk's (1981) finding that small, proximal goals aid attitudinal change seems to align with the findings and practice of this well-used psychotherapy (Beck, 1976, 1993).

Self-efficacy is also influenced by self-comparison and modelling of others' experiences, verbal persuasion and negatively influenced by certain physiological states, like fatigue and stress (Bandura, 1977; Bandura, 1997; Schunk, 1991; Zimmerman, 2000). As examples of other ways to develop self-efficacy in students, Schunk found that self-efficacy and academic attainment were significantly improved by having an adult model cognitive strategies compared to receiving didactic instruction (Schunk, 1981), as did simply verbally encouraging students to set their own goals (Schunk, 1985).

An implication for learning activity engagement would appear to be that offering small, proximal, achievable goals which involve visible activity for students might help previously disengaged students to see themselves engaging and therefore potentially challenge pre-set negative attitudes or beliefs. A further implication for learning activity engagement would seem to be that if students have already attained high self-efficacy in their learning experiences, then when presented with a new learning activity it is assumed this high self-efficacy would help students engage.

***Mastery orientation.*** According to the APA online dictionary of psychology (n.d.), a 'mastery orientation' is 'an adaptive pattern of achievement behavior in which individuals enjoy and seek challenge, persist in the face of obstacles, and tend to view their failings as due to lack of effort or poor use of strategy rather than to lack of ability'. With a mastery goal, a student wants to learn for the joy and satisfaction of accomplishment and proficiency. Missing, but implied, from the APA definition of mastery orientation is what others claim is its central precept — the belief that achievement is in direct proportion to effort, and it is this belief which sustains effort towards an outcome over an extended period (Ames, 1992; Weiner, 1985). So, a mastery orientation is an adaptive belief or affective cognition which sustains a person's effort such that he/she is more likely to achieve academic success.

At the learning activity level, having a mastery orientation would seem to predispose a student to engaging in new learning activities.

***Persistence.*** Persistence in the face of setbacks and failure is a hallmark of students with a mastery orientation and the intrinsic motivation to learn (Belenky & Nokes-Malach, 2013; Block & Burns, 1976; Covington, 2000; Deci, Ryan, & Koestner, 1999; Furner & Gonzalez-DeHass, 2011; Harackiewicz, Barron, Pintrich, Elliot, & Thrash, 2002; Martin, 2005; Pintrich, 2000; Yeung, Craven, & Kaur, 2012). Persistence is a behaviour aligned with mastery and success, and belief in the value of persistence is the related affective cognition involved which sustains the behaviour. Logically, persisting in a learning goal despite initial failure or failures is more likely to result in eventual success, particularly if students plan their work and manage the task with successful strategies.

***Planning and task management.*** In Martin's (2007a) model, planning includes chunking a large project down into doable tasks, setting reasonable targets in a diary or calendar and prioritising. Task management includes making sure study occurs somewhere without distractions. In both the research literature (Plenty & Heubeck, 2013) and professional literature (Burns, 2007), planning helps students succeed and not planning is associated with reduced engagement and motivation in learning. Using the same 11 factors in the Motivation and Engagement Scale (Martin, 2007b), Plenty and Heubeck (2013) found secondary school students were less motivated and engaged in mathematics compared to other subjects and that early adolescents scored lower on planning and task management, especially in mathematics. This suggests that helping Year 7 and 8 students to plan their work and use effective study strategies would help them engage in their study of mathematics.

**Maladaptive factors from Martin's Wheel which hinder engagement**

The three affective-cognitive dimensions of Martin's (2007a) Motivation and Engagement Wheel which impede engagement are uncertain control, failure avoidance and anxiety. The two behavioural patterns which negatively affect engagement are disengagement and self-handicapping. Anxiety was discussed in the sub-section 'Characterising mathematics anxiety' under section 3.2 The Affective Domain.

***Uncertain control.*** Uncertain control means a student is unsure what to do to improve or prevent poor outcomes. For example, in the context of learning mathematics, a test item on the Motivation and Engagement Scale (Martin, 2007b) is 'I'm often unsure how I can avoid doing poorly in maths'.

Weiner (1985) examined empirical studies of causality and found that perceived outcomes vary along three factors: locus (internal or external), temporal stability and controllability. For example, in a traditional mathematics classroom scenario, if a student fails a mathematics test, that student might think it was because he/she is not good at maths, that is, the cause was internal, stable and not under her control. Another student with the exact same test result might think she failed because he/she did not try hard enough, that is, the cause was internal, temporary and under her control. A final student who failed the same test might think her result was because the test was unfairly hard, that is, he/she attributed her poor mark to a cause that was external, temporary and not under her control.

For Martin (2007a), the perceived level of control a student has regarding outcomes is the factor which most affects students' motivation and engagement. So, if students perceive that they have little or uncertain control over outcomes, they will not be as motivated to exert effort to achieve a presented learning goal, and furthermore, this perception of low controllability will largely determine their responses to setbacks, failure, fear of failure and pressure (Martin, 2013; Martin et al., 2003).

***Failure avoidance and failure acceptance.*** Failure-avoidant students fear failure and can be anxious about their studies. For example, one of the items in the Motivation and Engagement Scale (Martin, 2007b), that tests for failure-avoidance is, 'Often the main reason I work at school is because I don't want to disappoint my parents'.  This seems to imply that these students will avoid engaging in learning activities if they think they will fail but could perhaps be induced to work, not for the intrinsic joy of learning, but to avoid negative consequences.

Failure-accepting students have withdrawn from studies, have low self-efficacy in regards to their school learning and do not try to avoid academic failure; they accept it as inevitable (Conley, 2012; De Castella, Byrne, & Covington, 2013; Martin et al., 2003; Pajares, 1996; Schunk, 1991).

***Self-handicapping and disengagement.*** In Martin's (2007a) Wheel, the final quadrant contains the maladaptive behavioural factors: self-handicapping and disengagement. Some students may self-handicap their studies by procrastinating and adopting other poor study habits or strategies so that they will have an ego-protecting excuse if they fail (Covington, 2000; Martin et al., 2003; Pintrich & De Groot, 1990). A Motivation and Engagement Scale (Martin, 2007b) test item for self-handicapping is, ‘I sometimes don’t study very hard before maths exams so I have an excuse if I don’t do as well’. For Martin (2007a; 2007b), disengagement is seen as a maladaptive behaviour. A test item for disengagement in the Motivation and Engagement Scale is, ‘Each week I’m trying less and less in maths’. Just as engagement is seen as multifaceted, non-engagement is equally rich.

**Practical aspects of Martin’s Wheel**

Martin’s (2007a) Motivation and Engagement Wheel gives teachers and researchers a model by which to plan for, include and assess pedagogical actions that facilitate, encourage or model the adaptive affective-cognitive and behavioural factors of engagement and motivation (self-efficacy, mastery orientation, valuing, persistence, planning and task management), and inhibit or address the maladaptive or impeding behavioural and affective-cognitive factors (uncertain control, failure avoidance, anxiety, self-handicapping and disengagement).

Teachers can foster students’ self-efficacy and persistence with the following measures:

(a) giving students challenging, but safe, tasks (Clarke, Roche, Cheeseman, & Sullivan, 2014; Ingram, Linsell, Holmes, Livy, & Sullivan, 2016; Russo & Hopkins, 2017) in which to experience mastery (Belenky & Nokes-Malach, 2013; Harackiewicz et al., 2002) and the intrinsic rewards of mastery orientation (Bandura & Schunk, 1981);

(b) arrange group tasks such that students can see success modelled and encourage each other on mastery goals (Mevarech, 1985); and

(c) praise effort and encourage personal goal setting (Bandura, 1991; Eccles & Wigfield, 2002; Locke & Latham, 2006; Mueller & Dweck, 1998; Schunk, 1991).

By setting personal goals, students will be practising planning and task management for which Plenty and Heubeck (2013) have demonstrated that early adolescents are particularly lacking in their mathematics studies, thus affecting their motivation and engagement. Such practices are likely to help disenfranchised students, those with a failure-avoidance approach to their learning or who are prone to self-handicapping, to see that other more success-oriented paths are available. By including references to cognitive behavioural therapy theory (Beck, 1976), Martin (2007a) seems to be suggesting that disengaged students could be supported to create and work towards achievable, chunked, proximal goals, and the achievement of which will likely challenge maladaptive beliefs.

Teachers can help students see the value of mathematics by presenting real life problems to solve (e.g., Gresalfi & Barab, 2011) and explaining (Stroet et al., 2013) or encouraging students to find out why and how each mathematics topic is important (Bjork, Dunlosky, & Kornell, 2013; Boaler, 2016). To address and prevent students experiencing uncertain control, teachers would make the aims of the lesson and the criteria of success explicit with inviting learning intentions (Hattie et al., 2017) and be ready with enabling prompts to support students who initially struggle with the presented task (Sullivan, Mousley, & Zevenbergen, 2006).

It appears Martin's (2007a) Motivation and Engagement gives teachers, counsellors and other practitioners a tool to help students explore, challenge and address less adaptive attitudes and behaviours which might be preventing students from achieving their potential: disengagement, self-handicapping, uncertain control, failure avoidance, and anxiety. It also makes clear what students could be aiming for and which current attitudes currently could be acknowledged and supported: high self-efficacy, mastery orientation, valuing, persistence, planning, and task management.

For this study, I chose Martin's (2007a) Wheel as a framework to cover, include and make sense of major pre-existing psychoeducational factors affecting students' engagement when presenting them with a learning task. Further social-cognitive factors are explained below.

### Social-cognitive influences

Social-cognitive factors (factors which an individual internalises by watching others; Bandura, 1991) have been found to influence students' approach to learning, their engagement level and achievement. The following topics are discussed here: achievement goal theories and approaches to learning; and mindset (growth or fixed).

#### Achievement goal theories and approaches to learning

Achievement goal theory (AGT) describes a two-by-two factorial matrix of firstly, a mastery or performance focus on learning goals, and secondly, whether students approach or avoid these foci (Ames, 1992; Dweck & Elliott, 1983; Elliot, 2005; Harackiewicz et al., 2002; Hulleman, Godes, Hendricks, & Harackiewicz, 2010). First conceived with three orientations (mastery-approach, performance-approach and performance-avoidance), these four, well-researched orientations (now including mastery-avoidance) affect how students will think and act regarding engagement and learning (Murayama & Elliot, 2009). These orientations appear to align or overlap with factors discussed under Martin's (2007a) Wheel.

A mastery approach (please refer to Mastery orientation above) is characterised by the intrinsic motivation of wanting to learn for its own sake. A student with a mastery-approach orientation will not need extrinsic motivation (rewards or punishments) to engage in the learning and will be less affected by academic performance social comparisons.

A student with a mastery-avoidance orientation fears losing knowledge and skills already gained and so will appear to engage in the learning but not for the intrinsic joy of learning.

Other students are motivated by their social comparison with others' performances and are split into two types: those with a performance-approach orientation and those with a performance-avoidance orientation. A performance-approach is characterised by the extrinsic motivation of wanting demonstrate competence to others (Elliot, 2005). Performance-approach oriented students want to appear smart and enjoy competing to obtain the highest score. These students are more likely to engage if external rewards (like recognition) are offered. Performance-avoidance orientated students perceive that they are unable to understand the content or achieve and, fearing that this will be found out by others, these students tend to disengage so they do not appear incompetent (Conley, 2012). Performance-avoidance appears to share common features with failure acceptance. It appears that the classroom culture and goal structure fostered by the teacher is paramount in helping students adopt a mastery-approach orientation through explicitly valuing persistence, effort and progress (Murayama & Elliot, 2009).

**Mindset**

Another social-cognitive influence affecting students' engagement is students' mindsets regarding the fixedness of intelligence and competence (Blackwell, Trzesniewski, & Dweck, 2007; Boaler, 2016; Dweck, 2006). If students have a growth mindset, they believe intelligence and the ability to achieve is not static but expands with effort; with a fixed mindset, students believe intelligence is immutably and genetically determined and the ability to achieve is static. Again, it appears that the teacher is instrumental in conveying that all humans have the aptitude for growth by giving praise for effort (not intelligence), but the peer culture is important too (Boaler, 2003, July; Hamm, Farmer, Lambert, & Gravelle, 2014). A peer culture which derides effort as students wanting to appeal to adults or take on adult values has a negative effect on engagement (Hamm et al., 2014; Juvonen, 2000; Sullivan, Tobias, et al., 2006).

## 3.4 Research on Early Adolescents' Engagement

In this section, I explore some reported psychosocial attributes of early adolescents which seem to have repercussions for engagement in mathematics classes. First, adolescence is described as a normal period of both flux and adjustment. Second, I discuss that it is in this unstable period that students often formulate their level of future study of mathematics (Tytler et al., 2008) which in turn affects their life opportunities (e.g., Finnie & Meng, 2001). Third, I outline important studies which suggest that early adolescents might tend to be more affected by peers compared to other age groups of students. Fourth, I outline various mechanisms which early adolescents have been found to employ to save face amongst peers. Fifth, I explain how these psychosocial effects might affect students in mathematics classes in particular. Lastly, I outline strategies which might be employed to utilise or work within these psychosocial drives for improving the engagement of lower secondary students in mathematics.

### A time of normal, but challenging, changes

Firstly, adolescence is a time of changes, but these changes are normal and most adolescents navigate through this time well (Steinberg & Morris, 2001). Early adolescents, at the onset and early stages of puberty, generally thought to be between 10 and 14 years old (but in the past was reported as later e.g., Berndt (1982) states 12 to 16 years), are in the early stages of transition from childhood to adulthood; they experience many physical, sexual, psychosocial, emotional, moral and cognitive developments. Additionally, it is during this time of rapid and personally significant developmental changes that students undergo yet another change — transition from primary to secondary school. Although change is often rewarding and can bring new possibilities, change is, by definition, unsettling and challenging. On the other hand, the changes early adolescents experience are normal and most adapt and progress well (Steinberg & Morris, 2001).

### Students tend to decide about mathematics by age 14

Students tend to make up their mind about their future involvement level in mathematics by about the age 14 — according to an Australian Government review of engagement in science, technology, engineering and mathematics (STEM) subjects across the primary to secondary school transition (Tytler et al., 2008). So, it appears that it is largely within this period of early adolescence and transition that educators have the last chance to positively influence students to continue their study of mathematics. Continued study of mathematics helps keep students' opportunities open, be enabled with high numeracy, improve their employment and future study prospects (Cohen Kadosh, Dowker, Heine, Kaufmann, & Kucian, 2013; Durrani & Tariq, 2012; Finnie & Meng, 2001; Hanushek et al., 2015) and hopefully foster an appreciation for or valuing of mathematics (Covington, 2000; Hamm et al., 2014; Martin et al., 2015; Mason, Stephens, & Watson, 2009). Therefore, there is a sense of urgency to help students engage in their studies of mathematics in early adolescence but doing so requires working with or around those psychosocial pressures which tend to favour disaffection in mathematics.

**Early adolescent influence of peers and peer conformity**

It appears evident that all humans are affected by the opinions of others (see, for example, classic studies by Festinger, 1954), but according to Kosten, Scheier, and Grenard (2013) and Steinberg and Monahan (2007) for many early adolescents this phenomenon is heightened in that there is a noticeable tendency to alter opinions to those of peer expectations and to that of their friends or friendship groups (Brown & Larson, 2009). This ‘conformity reflects the willingness of an individual to adopt social rules or group norms’ (Kosten et al., 2013, p. 566), and suggests that the individual is willing to suppress his or her own thoughts in exchange for belonging to a group. For example, in an amalgamation of three studies, two longitudinal and one cross-sectional, Steinberg and Monahan (2007) found that young people’s ($n$ = 3,600+; aged 10 to 30 years) self-reported resistance to peer influences increased with age, being lowest at age 10, increasing slightly at 12 but largely remaining at a lower level till just after age 14. From 14 years to 18 years, Steinberg and Monahan observed a linear progression in ability to resist peer influences. After eighteen years of age and until 30 years of age (the oldest participants in the study were aged 30 years), the researchers discovered that self-reported ability to resist peer pressure plateaus again, such that, as Festinger (1954) found, social comparisons and influences can still alter opinions, but not as readily as for early adolescents.

As found by Kosten et al. (2013), resistance to peer expectations also increases with social confidence and by having an internal locus of control (a belief that situations can be influenced by oneself), as opposed to social anxiety and an external orientation (Anderson, Hattie, & Hamilton, 2005; Kulas, 1996; Rotter, 1966). So, a socially confident adolescent with an internal locus of control is more likely to resist peer influences than a socially anxious adolescent who sees situations as being outside of his or her control. The latter is more likely to be persuaded to accept group thinking and a small minority can also be influenced by peers to partake in risky or delinquent behaviours (Kosten et al., 2013). However, most risky or antisocial behaviour that adolescents engage in seems to be experimental rather than a manifestation of an ongoing trait (see Steinberg & Morris, 2001).

As summarised by Steinberg and Morris (2001), perhaps counter to conventional wisdom (Brown & Larson, 2009), peer conformity and peer influences are nuanced for adolescents and change with time rather than being unidirectional, static and homogeneous throughout the adolescent population. Adolescents can influence their peers both positively and negatively; that is, adolescents can influence peers towards pro-social ends and greater academic involvement (Mounts & Steinberg, 1995; Wentzel & Caldwell, 1997), as well as sometimes influence peers towards risk taking, drug use and delinquent behaviour (Brendgen, Vitaro, & Bukowski, 2000) and to under-perform academically (Wentzel & Caldwell, 1997). This suggests that the tendencies of early adolescents are not fixed and are open to positive (and negative) influence.

Homophily, the tendency for those in a friendship group to be similar, is evident in but not exclusive to adolescents. It can be explained by a process of selection of like-minded people, socialisation effects once the friendship has been established (social pressures which increase the similarity between friends) and active de-selection of people who start to hold dissimilar opinions or interests (Kandel, 1978). Therefore, there are multiple facets to apparent youth conformity and peer influences.

**Early adolescents saving face and competing for attention**

Juvonen (2000) found that early adolescents tend to explain lower-than-expected school performance in a face-saving way which affords them three benefits: (a) it brings them sympathy from peers; (b) helps retain inclusion in their friendship group; and (c) elicits approval from their liked teachers. In regards to low effort (low effort is argued here as akin to low engagement), early adolescents from Finland were more likely to declare that poor academic performance was due to low effort if communicating directly to peers, thereby presenting as honest to their friends, but not if communicating directly to teachers, unless they did not like them. Juvonen argued that students will not try to appease teachers they do not like, and perhaps also there is a slightly retaliatory component to a student declaring to a disliked teacher that he/she would not put in effort (which Juvonen explains that students tacitly agree is what teachers want to hear). Also, early adolescents thought a hypothetical person who was smart, but did not put in any effort, was seen as being more likely to be popular than a hardworking and high achieving peer (Juvonen, 2000).

Juvonen (2000) explains that when there are normative assessments, students are competing for grades, so an individual who puts in effort is seen as competing for attention and grades and is therefore not liked. Furthermore, Juvonen found that putting in effort is seen by students as inversely proportional to ability, that is, a person puts in high effort to compensate for low ability, so the more effort a person puts in, the lower their actual ability must be.

**Mindsets and effort**

The amount of effort students are willing to exert relates to Dweck's (1986, 2006) work on mindsets, as discussed above, where students (and teachers) with a fixed mindset believe that intelligence and ability are set, so perceive that expending extra effort is futile. Students with a growth mindset believe that extra effort and actively seeking effective strategies favours profound learning and the development of intelligence and ability. That is, with a fixed mindset, students might view putting in effort as only useful for social or personally detrimental reasons — to ingratiate oneself with teachers or compensate for poor natural ability. Therefore, students save face by not putting in effort as it would signal to peers that they really have high (latent) ability. This also would seem to put those with low ability, high social anxiety and high need for peer conformity at a huge disadvantage — if they work at improving their understanding, they risk being shown up for having low ability and risk being shunned by their peers.

**Early adolescents' psychosocial traits and engagement in mathematics**

The heightened tendency for early adolescents to be swayed by peer norms and friends' opinions, to view effort as weakness and as ingratiatingly aligning with adult values and their propensity to employ face-saving measures to retain friendship group approval suggests that pedagogies, especially in mathematics where disengagement levels can be relatively high amongst early adolescents (Green et al., 2012), would be more effective in eliciting effort if they are student-centred, are dialogic-based, and have mainly non-normative assessments. This would appear to help diminish academic comparisons, take the attention away from the teacher and involve students in groups, rather than mainly individual activities. Perhaps offering class-wide group projects might alleviate some of the social forces working against engagement and effort in early adolescent mathematics classes.

Focussing on adolescent attitudes in the mathematics classroom, Martin et al. (2012) found that engagement in mathematics for early adolescents was influenced by, among other factors, perceptions of class enjoyment. This ties in with the findings of Steinberg and Monahan (2007), Kosten et al. (2013) and Newman, Lohman, and Newman (2007) that early adolescents have a tendency to be influenced by peers and suggests that this influence extends to, but is not particular to, the mathematics classroom. It seems plausible that if a range of interesting group-work activities was offered in the mathematics classroom which students could not only enjoy individually, but see fellow class members enjoying, then students might be able to conclude collectively that this kind of mathematics learning is engaging. Tellingly, in mathematics education, Sullivan, Tobias, et al. (2006) found in interview data ($n$ = 50) that classroom culture and peer influence was a strong, and often negative, determinant of engagement for Year 8 students. Also as discussed above, especially in normatively assessed classrooms, peer group and social influences seem to affect what students say might be the cause for poor academic performance, and presumably, engagement. So, there appear to be more social forces pulling engagement down in mathematics. It seems enacting the same mechanisms in the opposite direction, students seeing each other *enjoying* mathematics, would be a logical strategy to trial.

In mathematics classrooms and in regard to engagement of early adolescents, it appears from Juvonen (2000) that some students might state that they are uninterested in or have low ability in mathematics, but these positions might be stated for social reasons, and are not necessarily genuine indicators of interest or ability. That is, if the group opinion (Festinger, 1954) appears to be that mathematics is boring or irrelevant, then it is likely that some in that social group will feel discomfort if they express an alternative viewpoint or experience. If early adolescents are involved in activities which they enjoy and, importantly, can see others enjoying or perceive others as enjoying (Martin et al., 2012), that would seem to be likely to improve overall engagement, and conversely, if the perception is that others are not enjoying the class, this in turn would likely reduce stated individual engagement and enjoyment.

Juvonen (2000) found that students who do not like their teacher might verbalise that they did not put in effort (engage in the subject) as a means of retaliation rather than as a reflection of the actual level of interest. That is *not* to say that every opinion an early adolescent student makes is suspect and influenced by peers or for an ulterior motive. Indeed Kosten et al. (2013) found that nearly half of the middle school students in their study were not particularly swayed by peers and, though admittedly in a different context, only a small proportion of students, 9%, would be prepared to engage in deviant or anti-establishment activities especially if doing so helped or might help a friend. Rather, there seems to be a complex mix of influences in the early adolescent classroom and publicly voiced claims from students of disengagement in the mathematics classroom might be overstated. It would seem prudent to obtain multiple measures of engagement or disengagement to ascertain a complete picture.

## 3.5 Teacher Effects and Pedagogical Choices

In this section, I briefly outline teacher influences on student engagement and then effective pedagogies which, as argued here, seem likely to also being engaging pedagogies.

### Teacher influences

Students' engagement in mathematics is affected by their teacher's perceived level of enjoyment and enthusiasm (Frenzel et al., 2009). As discussed above, the mathematics teacher is instrumental in helping students to embrace a mastery approach and foster a growth mindset in mathematics (Boaler, 2016). Also, the expectations of the teacher shapes students' engagement in mathematics (Megowan-Romanowicz et al., 2013) and lastly, a warm relationship with the teacher, who knows each student's capabilities, background and interests, bolsters students' engagement with mathematics (Attard, 2013, 2014; Hattie, 2012).

**Effective pedagogies**

Effective pedagogies, that is, those which increase the academic outcomes of students, would seem logically to be also engaging pedagogies. That is, if it is accepted that engagement is the committed involvement in learning (that is, the behaviours and mental processing directed towards learning goals associated with interest or enjoyment; please refer to the working definition of engagement in section 4.3 Engagement — Definitions and 'Grain Size'), then plausibly, unless the learning gains were not made with the students being intrinsically motivated, students would have had to engage in learning to make academic gains.

**Deep, relevant, rigorous, transferable learning**

Newmann, Marks, and Gamoran (1996) advise that pedagogies need to be authentic, that is, focussed on deep, relevant, rigorous, transferable learning. These scholars had observed activities conducted under the banner of student-centred constructivism which might have looked like learning engagement but were actually just busyness. Newmann and colleagues define 'authentic academic achievement through three criteria: construction of knowledge, disciplined inquiry, and value beyond school' (p.282). These criteria seem reasonable from an educator's viewpoint to judge effective pedagogy, however, it appears for students to feel engaged, although apparently agreeing with the need for the learning to be valuable beyond school, they might give prominence to different criteria.

**Pedagogies in which students seem to engage**

Attard found in a longitudinal study starting with higher-achieving Year 6 students in mathematics ($n$ = 20), that engagement in mathematics was high after transitioning to secondary school if the Year 8 students were experiencing 'a variety of pedagogies that were student-centred, interactive, and relevant to their lives outside school' (Attard, 2013, p. 583). Conversely, if students were experiencing teacher-centred pedagogies with little effort to make connections to outside school, the students' engagement suffered. This appears to be in line with other research findings suggesting student-centred constructivist pedagogies are more engaging for students (Noyes, 2012). So, it appears the ideal pedagogies to be effective and foster students' engagement in mathematics would be student-centred, interactive and would rigorously build knowledge which is relevant and transferable outside school. For example, a pedagogical approach which seems to satisfy criteria for promoting rigorous and relevant engagement in mathematics is posing rich, challenging, open-ended problems for students to solve (Russo & Hopkins, 2017; Sullivan & McDonough, 2007; Sullivan, Mousley, et al., 2006).

***Perceived level of enjoyment and peer influences.*** For students, the perceived level of fun or enjoyment in the mathematics classroom has been found to influence engagement (Attard, 2011a; Martin et al., 2012). As discussed above in section 3.2 The Affective Domain, Martin et al. (2012) found that individual students' enjoyment of mathematics was both a strong predictor of future selection of the subject and had a strong protective effect against disengagement for middle years students and, furthermore, that students' engagement in mathematics was affected by the perceived level of fun in the classroom.

Attard (2011a) found that Year 6 students ($n$ = 20) recalled hands-on lessons were the most fun including those with 'physical activity, active learning situations involving concrete material, and/or games' (p. 371). However, Attard advised that to be truly engaging, games' foci should be on learning mathematics and not on competition so as not to alienate and discourage students who might regularly lose games (also see Olson, 2007).

***A pedagogical approach used in this study***. As intimated in Chapter 2: Student Generated Media and Fraction Concepts, it was planned that a pedagogical approach which appears to be seldom used in secondary mathematics education, students generating digital media, would be utilised to give students potentially engaging activities. It was anticipated that students (a) would value using digital equipment; (b) would enjoy being creative; (c) would enjoy the hands-on activities; (d) would see classmates enjoying the activity and the learning; (e) would value the relevance to the outside world in that they would be creating content for others; (f) they would be dialoguing with classmates to discuss the ideas; and (g) the students would have the goal of showing the finished project to peers as a motivating impetus to work diligently to a high standard. As discussed in the three results and discussion chapters, these ideals were not necessarily met.

**Peer-to-peer pedagogies**

In undergraduate studies, peer assessments have been found to be worthwhile for students. Smith, Cooper, and Lancaster (2002) found that psychology students asked to develop marking criteria and assess class members' posters were wary of the approach before implementation but eventually came to appreciate the transparency of the approach, found it demystified assessment somewhat and they developed greater confidence in the peer marking process. Here, it was thought peer assessments might help early adolescents engage in and appreciate assessment, especially if the assessment was for and of an e-learning module with no academic consequences.

A rigorous meta-analysis has found peer tutoring improves academic outcomes (Leung, 2015). This pedagogical approach can be engaging for students. For example, in mathematics education, Ginsburg-Block and Fantuzzo (1997) found that the reciprocal peer teaching group showed higher achievement outcomes, more social acceptance between participants and more on-task behaviours compared to those in the control group with students in Years 4 and 5. These findings helped inform the plan to include peer-to-peer explanations via student-created videos and animations in the project.

**Effective pedagogies according to Hattie's synthesised meta-analyses**

For an efficient and comprehensive analysis of the effectiveness of pedagogical actions, and postulating that more effective strategies are also more engaging, I turn to extensive and influential work by John Hattie. Hattie (2009, 2012) has synthesised over 900 meta-analyses into a continuum of educational achievement effect sizes calculated using Cohen's (1988) co-efficient, denoted as *d*, such that mean difference between the treatment group and the control, or end of treatment and the beginning, is divided by the standard deviation. During a year of teaching, Hattie explains that the average improvement in achievement is between $d = 0.20$ and $d = 0.40$. An effect size of $d = 0.40$ is considered a medium improvement for an intervention, program or approach and $d = 0.60$ is a large effect. Hattie identified 138 factors affecting education from contributions from the student, home, school, teacher, curricula and, as very briefly outlined here, teaching approaches.

Hattie's synthesised meta-analyses have been criticised as loading decontextualised hegemonic scrutiny onto teachers (e.g., McKnight & Whitburn, 2018), but I refer to Hattie's work for efficiently aiding teachers (myself included) to make research-based decisions whilst considering the context and for succinct information on pedagogies. Some effective, pertinent-to-this-study pedagogical classroom approaches, practices or conditions for teaching mathematics identified by Hattie (2009; 2012) are presented in Table 3.1 in descending order of effect size.

A selection of these pedagogical approaches would seem to be likely to help students engage in their studies. Contrarywise, allowing students to control what they are learning ($d = 0.04$) and web-based learning ($d = 0.18$) appear to be much less efficacious. Interestingly, in Hattie's (2009, 2012) amalgamation of meta-analyses, problem-based learning (as contrasted with problem-solving teaching, $d = 0.61$) seems to have a low achievement level overall ($d = 0.15$), but when separated out into components, the value for surface level learning is very low ($d < 0$) but very high ($d > 0.6$) for deep learning. So, inclusion of other pedagogies to effectively cover surface learning would seem to be needed with problem-based learning.

As a cautionary note, while it seems logical to assume that approaches which are highly effective in increasing academic scores are likely to be compelling and engaging for students (involve action and thinking directed towards learning goals and are associated with interest or enjoyment), this is not certain. Hattie's (2009; 2012) analyses do not always reveal if less efficacious approaches in terms of academic output are or are not engaging for students. For example, students rated that choosing what they learn to be somewhat engaging despite not achieving high academic gains (d = 0.04). On the other hand, if students are not achieving learning goals, they are not, by most definitions including the definition chosen for this study, engaged in learning.

Table 3.1

*Selected Effective Pedagogical Approaches in Rank Order from Hattie (2009; 2012)*

| Pedagogical approach or practice | Effect size, *d* | Notes |
|---|---|---|
| Providing formative evaluation | 0.90 | Seeking and acting on honest feedback from students on the effectiveness of innovations and programs |
| Classroom discussion | 0.82 | Fostering classroom discussion with strategies including increased student talking and reduced teacher talking |
| Feedback | 0.75 | Providing information learners can integrate into their next learning step |
| Teacher-student relationships | 0.72 | Including teacher being non-directive, empathetic, warm and encouraging higher-order thinking |
| Meta-cognitive strategies | 0.69 | Higher order control, planning and selection of strategies demonstrating ‘thinking about thinking’ |
| Problem-solving teaching | 0.61 | Identifying cause of a problem then creating and discerning solutions |
| Direct instruction | 0.59 | Learning intentions and success criteria are known, teacher models successful examples, checks for understanding and offers opportunities for guided practice, consolidation and independent practice |
| Mastery learning | 0.58 | Providing cooperative environment, clear explanations and feedback towards mastering concepts and skills |
| Worked examples | 0.57 | Showing steps from a problem statement to a solution |
| Challenging goals | 0.56 | Teachers set challenging, not ‘do your best’, goals |
| Peer tutoring | 0.55 | Especially effective if student-managed |
| Co-operative learning | 0.41 | Enhancing interest, group problem-solving and peer involvement |

*Note.* Effect size, d = [mean $_{\text{treatment}}$ – mean $_{\text{control or pretreatment}}$]/SD; Selected effects from ‘*Visible learning: A synthesis of over 800 meta-analyses relating to achievement,’* by J. Hattie, 2009, London, UK: Routledge, and *‘Visible learning for teachers: Maximising impact on learning’* by J. Hattie, 2012, London, UK: Routledge.

## 3.6 Physical Factors

Substandard physical learning environments (e.g., high noise, poor lighting and poor ventilation) tend to be associated with poorer engagement and learning outcomes but learning gains have not been consistently found once minimum standards have been met (see Higgins, Hall, McCaughey, Wall, & Woolner, 2005; Leiringer & Cardellino, 2011; Woolner, Hall, Higgins, McCaughey, & Wall, 2007). For example, nearly three decades ago, Hathaway (1995) found children in Canadian schools working under full-spectrum-emitting lighting had both better health and learning outcomes than those working under some other artificial lighting sources. However, once the lighting was changed to full-spectrum lighting, further academic gains would not be expected by trying to enhance the lighting further.

### Physical environmental and a classroom situational influence on engagement

The physical environment and related influences are discussed here briefly as forming part of the picture of the environment in which a learning activity is presented to a class. All these factors were not measured or observed but are outlined here in an attempt to offer more description of engagement-affecting elements so that the theoretical framework of this study is given sufficient context. Some of these factors would seem to be under the control of the teacher, for example, opening the windows in a stuffy room and opening blinds, when feasible, to allow natural light into the classroom. Other factors might be less under the control of the teacher including the type of artificial lighting installed in the classroom and the timetabling, although plausibly teachers could affect change.

### A potential situational classroom influence — time of day

The time of day in which classes are offered seems to affect students' ability to concentrate in sometimes anticipated ways, and in other ways, less so. As might be expected, Anderson, Petros, Beckwith, Mitchell, and Fritz (1991) found that long-term memory word retrieval decreased throughout the day ($n$ = 99) for female college students whose questionnaire responses indicated them to be ‘morning type’ and increased for those found to be ‘evening type’. As reviewed by Hines (2004), there are conflicting reports of the effect of time-of-day on cognition and it may be that more cognitively adept individuals are able to override circadian cues from light level and body temperature (as a measure of alertness) to concentrate when needed and other individuals seem more susceptible to time-of-day learning, but not in necessarily predictable ways. In an unanticipated finding, Klein (2004) found that middle years students’ grade point averages were lower when classes started after the mid-morning break and the lunch break, but for the classes starting one hour later in both cases, the grades improved. As might be expected, mental fatigue rather than time-of-day effects might explain what teachers note as a slump in afternoon alertness of middle years students (Klein, 2004). Interestingly, Frings (2011) found with military personnel that fatigue-reduced alertness could be largely mitigated when people solved problems in groups rather than individually. Referring to middle years students in mathematics, it does not seem possible to generalise about the time of day students should be studying mathematics, but for individuals, the time of day may affect engagement, and after concentrating for a full day, fatigue may be an issue later in the afternoon.

### 3.7 Concluding this chapter

I had four purposes for this chapter: (a) to explore the range of influences, both positive and negative, which have been found to impact engagement as reported in the literature and would feasibly impact engagement at the learning activity level as presented in this study; (b) to understand the time frame, context and level at which these factors operate — psychological, social or environmental; (c) to do this to help interpret the findings; and (d) to do this to better understand the construct of engagement itself through that which affects it. Furthermore, I needed know which factors particularly pertained to early adolescents and mathematics education.

I found from this literature review that beliefs can be surprisingly difficult to influence. The belief an individual has in their own ability to successfully handle challenges, self-efficacy, is an important positive determinant of engagement in mathematics education, but it seems to require intervention, especially from a teacher, to improve it. Although I suspected so, it was also interesting to confirm that for many people, negative attitudes to mathematics are conceived and fostered by experiences at school. These findings have implications for this study in that students may have pre-formed beliefs which would seem to impact, and may not be altered by, a short-term project.

This literature review has revealed that enjoyment and boredom, polar opposites according to the research by Pekrun and associates (2017), might be helpful indicators of the students' level of learning engagement. They found enjoyment, an activating and pleasant emotion associated with students feeling in control of the outcome and valuing the activity, has been found to be elicited during active learning, so during engagement; and boredom, a deactivating and negative emotion, was elicited during when students felt limited control and low valuing of an activity. So, boredom would possibly be an indicator of the opposite of engagement.

Using Martin's Wheel (2007a) to organise the discussion of psychoeducational factors which influence engagement has shone light on the complexity and direction of interventions to help students achieve. Interestingly, including cognitive behaviour therapy perspective to changing maladaptive behaviours and beliefs has opened up the possibility that students might profit from having small proximal challenges to achieve and to watch themselves and others achieve.

This literature review has revealed that early adolescents can tend towards peer conformity and aligning expressed beliefs to those of peers, but this is not a global finding. It appears early adolescents can employ face-saving strategies to explain poor performance especially in normatively assessed classes and can put pressure on peers to diminish effort, and presumably engagement, in their study of mathematics. This might be mitigated by avoiding normative assessments, employing student-centred, hands-on, dialogic based, but still challenging, pedagogies. Another finding of note is that students are receptive to and tend to be influenced by how they perceive classmates' level of engagement. This seems to imply that students could improve their expressed level of engagement by seeing classmates enjoy an activity.

From Hattie's (2013) syntheses of meta-analyses, it appears providing formative evaluations, using class discussions effectively, problem solving approaches and direct instruction have afforded students higher academic outcomes, and presumably are engaging approaches. Also, from Attard (2011a; 2013) and Frenzel et al. (2009) it seems the relationship with the teacher is important in maintaining student engagement and that students value fun, relevance to the outside world and hands-on activities Attard (2011a; 2013).

Lastly, it seems that some physical factors can impinge upon students' engagement, but once the environmental problem has been addressed, further gains are not expected.

In concert, these effects have underscored how complex, and potentially fragile, maintaining or gaining engagement can be in the mathematics classroom with early adolescents. However, for each of the negative influences considered, there appear to be measures which can be undertaken to help address them. Also, these factors, for me, help build a picture of the nature of engagement as it being shaped by prior individuals' prior experiences and their interpretations of them, such that, perhaps one of the most important duties of a teacher is to help foster students' engagement especially through encouraging students' effort, helping students to value mathematics beyond the classroom and by choosing pedagogical approaches based on research.

If, as stated by Sinatra et al. (2015, p. 1), 'Engagement could be described as the holy grail of education' then as a researcher and teacher, I need to know what engagement is, both broadly and at the learning engagement level. The theories explaining engagement need to be described and relationships between them elucidated, or perhaps proposed. These are the areas explored in the next chapter, Chapter 4: Defining engagement and the Theoretical Framework.

# Chapter 4: Defining Engagement and the Theoretical Framework

The first use of the term ‘engagement’ is reported to be by Mosher and McGowan in 1985 noting that governments could mandate students’ school attendance but not their willingness to be involved in their studies (Appleton, Christenson, & Furlong, 2008). According to Eccles (2016), academic engagement started to gain prominence as an education and psychology research construct in the mid-1990s. At this time in the US, Eccles headed a multidisciplinary think tank to explore psychological and social factors affecting children’s academic achievement. Since the 1990s, the interest in researching engagement has continued to surge upwards. A broad search in Psychinfo by Azevedo (2015) found more than 32,000 articles on engagement since 2000.

Interest in engagement has grown specifically in the mathematics education literature too. Prior to the 1990s, it appears mathematics education research focussed on the conceptualisations of mathematics, how they are learned and how to teach them rather than how to engage students in their study of mathematics (see Watt & Goos, 2017). Interestingly, despite decades of engagement research in psychology and education, and specifically in mathematics education, it appears scholars are yet to agree on what it is.

## 4.1 Signposting this Chapter

In this study, I explore engagement at the learning activity level of Year 8 students in their mathematics class while they create and appraise digital media and other elements for an e-learning module in fractions. In this chapter, I show extant critiques on how engagement has been characterised, examine how engagement, disaffection and disengagement have been defined in dictionaries and the literature and then offer working definitions of these terms for this study. I explain, by using a theoretical framework, how I have attempted to make sense of various theories of engagement and the multiple antecedent and ongoing influences which have been reported to affect learning engagement of students in the mathematics classroom.

In section 4.2 Extant Critiques of the Characterisation of Engagement, I show commentary from Eccles (2016) and Boekaerts (2016) used to help guide the choice of definition of engagement used in this study (and therefore help define its opposites, disaffection and disengagement) and to assist in shaping this study's theoretical framework.

In section 4.3 Engagement — Definitions and 'Grain Size', I review definitions of the key terms used in this study from dictionaries and from the literature — engagement, motivation, disengagement, disaffection and compliant engagement. The 'grain size' of engagement is explained. The control value theory of achievement emotions, CVTAE, (Pekrun, 2006), already described in Chapter 3: Influences on Engagement, is re-outlined so the importance of including emotions in the definitions of engagement and disaffection and of CVTAE in the theoretical framework is clarified for this study. I state the working definitions of engagement, disaffection and disengagement used in this study and show the resources draw upon in devising them.

In section 4.4 Two Theories of Engagement, I describe two theories often used in mathematics education to explain engagement (Watt & Goos, 2017): (a) expectancy value theory (EVT, Eccles et al., 1983; Wigfield & Eccles, 2000) and (b) self-determination theory (SDT, Deci & Ryan, 1985; Deci & Ryan, 2000).

In section 4.5 Theoretical Framework for this Study, I illustrate and explain this study's theoretical framework. The visual arrangement of the framework, with positive factors at the top and inhibiting factors below, was informed by Martin's (2007a) Motivation and Engagement Wheel (please refer to discussion in Chapter 3: Influences on Engagement, section 3.3 Psychoeducational and Social-Cognitive Factors) and shaped by extant critiques and commentary on different conceptualisations of engagement (Boekaerts, 2016; Eccles, 2016). It is framed at the learning activity level and shows possible links between EVT, SDT and CVTAE. The framework is focussed on students' responses to a learning activity and displays the trajectory towards, away from or parallel to, the learning goal. It indicates how emotions might be both antecedent to and elicited by learning engagement.

### 4.2 Extant Critiques of the Characterisation of Engagement

Although the concept of engagement has been researched since the 1990s, many scholars (e.g., Azevedo, 2015; Christenson et al., 2012; Sinatra et al., 2015) have highlighted that a single definition of engagement is yet to be agreed upon. Although some theorising of engagement has been undertaken at the learning activity level (e.g., Skinner & Pitzer, 2012), there seems to be even less characterisation of the construct in this area. In this study, to help conceptualise engagement appropriately for learning activities, I sought critiques of the concept to guide the process.

Educational psychology theorists in engagement research, Boekaerts (2016) and Eccles (2016) have reviewed and offered multiple critiques of engagement research. As well as calling for consistent theorising of engagement, three of these critiques seem to have particular implications for this study. Firstly, both theorists noted that emotions need to be explicitly characterised within a conceptualisation of engagement. As queried by Eccles (2016, p. 74), 'is affect a part of engagement or a precursor to engagement?' Secondly, Eccles has explained that the context and duration of the engagement needs to be made clear. Lastly, both Boekaerts and Eccles challenged scholars to be explicit on how learning engagement relates to learning goals.

### 4.3 Engagement — Definitions and 'Grain Size'

Naturally, to study, observe, explore and report on engagement, the researcher needs to be clear on his or her conceptualisation of it. Considering this exploratory case study is based on learning activities, each with specific goals, and in line with the critiques of Eccles (2016) and Boekaerts (2016), I sought a definition of engagement which characterises the role of goals. Also, engagement is often reported as a multifaceted construct comprised of three dimensions: behavioural, cognitive and emotional engagement (Fredricks et al., 2004) but, as outlined below, not every definition of learning engagement has included the cognitive and emotional components. Considering mental processing or 'heads on' thinking (Skinner & Pitzer, 2012, p. 22) is integral to mathematics education, I sought a definition of engagement which includes the characterisation of cognition. As discussed briefly below and in Chapter 5: Research Philosophy, Methodology and Methods, it appears emotions elicited during activities might be helpful markers of engagement and disaffection, so I sought a definition which included the characterisation of emotions.

**Broad definitions of engagement and motivation**

For many influential educational theorists and researchers, motivation and engagement are linked (e.g., Grootenboer & Marshman, 2016; Pintrich & De Groot, 1990; Ryan & Deci, 2000). This seems to imply that engagement needs to be understood in terms of motivation. To give a broad overview of the concepts of engagement and motivation, first dictionary meanings are sought.

**Dictionary definitions of engagement**

Engagement does not appear to have a standard definition in either education or psychology (Boekaerts, 2016; Christenson et al., 2012; Eccles, 2016; Sinatra et al., 2015). Indicatively, neither the Oxford Dictionary of Education (Wallace, 2015) nor the American Psychological Association's (APA) online dictionary of psychology (n.d.) have an entry for engagement. Turning to etymology, 'engage' comes from Old French meaning *to pledge* and its various meanings of commitment, betrothal, employment and involvement stem from this meaning (Barnhart, 1988). In line with this etymological definition and supported by a combined dictionary search by Fredricks et al. (2004) engagement could be taken to mean, in a broad or everyday sense, *committed involvement*.

**Dictionary definitions of motivation**

Motivation is derived from the Latin word meaning *to move* (Barnhart, 1988) and involves the impelling towards something. According to the APA online dictionary of psychology (n.d.), motivation is 'the impetus that gives purpose or direction to behavior and operates in humans at a conscious or unconscious level'. Interestingly, in this definition, motivation is tied with behaviour. According to the Oxford Dictionary of Education (Wallace, 2015), motivation in education is the 'will or incentive to learn'.

**Implicit role of motivation and explicit role of behaviour in defining engagement**

It appears motivation definitions in the education literature often include impelling, willingness, the potential, energy or drive towards learning as a goal, and engagement involves the actions or behaviours which are undertaken to achieve it. For example, Liem and Martin (2012, p. 3), based on earlier work by Martin (2007a), defined motivation in education as ‘individuals’ energy and drive to learn, work effectively, and achieve to their potential’, and engagement as ‘the behaviours aligned with this energy and drive’. Similarly, Gettinger and Walter (2012, p. 653) stated that motivation is the ‘willingness to invest time in learning’ and student engagement is the ‘actual involvement or participation in learning’. These definitions seem to show that motivation is antecedent driver of engagement. Also, Skinner and Pitzer (2012, p. 24) stated that ‘engagement refers to energized, directed, and sustained action, or the observable qualities of students’ actual interactions with academic tasks’. Each of these definitions of engagement explicitly state that engagement involves actions or behaviours.

Motivation can either be extrinsic — manipulated, shaped or reinforced with rewards and punishments — or intrinsic — directed towards goals undertaken for their own sake, like the satisfaction of mastering a concept or skill (Covington & Müeller, 2001; Deci et al., 1999; Ryan & Deci, 2000). Intrinsic motivation has been linked with increased creativity and high-quality learning (Ryan & Deci, 2000). It appears that deep engagement with learning would be intrinsically motivated. Deep engagement seems to resonate with the conceptualisation by Reeve (2012) who argues that learning engagement has an extra more goal-focussed and agentic component as well as the ‘classic’ behavioural, cognitive and affective components.

For Hannula (2006, p. 165), ‘motivation is conceptualised as a potential to direct behaviour through the mechanisms that control emotions’. This suggests motivation drives behaviour, and through that process, emotions are evoked (and presumably expressed or suppressed) and in turn, emotions influence the behaviour.  Motivation is ‘structured through needs and goals’ and ‘goals are derived from needs’ (Hannula, 2006, p. 165). This seems to suggest, that for Hannula, motivation is directed towards a goal and the behaviour enacted from that motivation and towards that goal in education could be what others (e.g., Gettinger & Walter, 2012; Liem & Martin, 2012) call engagement. Attard (2014) argues that in mathematics education, motivation is reciprocally affected by engagement, that is, as engagement increases with high quality tasks, positive pedagogical relationships and repertoires that involve students in their learning, that motivation increases.

**Control value theory of achievement emotions and emotions in engagement**

Hannula's (2006) conceptualisation of emotions in motivation appears compatible with that of Pekrun, Frenzel, Goetz, and Perry (2007), from the perspective formed by the control value theory of achievement emotions, CVTAE (Pekrun, 2006). As described in Chapter 3: Influences on Engagement, Pekrun and colleagues (2007) theorised and found both that (a)'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'; and (b)'emotions influence cognitive resources, motivation, use of strategies, and self-regulation vs. external regulation of learning' (p. 16). That is, according to CVTAE, elicited emotions in achievement settings are either positive or negative depending on whether the students value the task or not, feel they can control the outcome or not and whether the outcome, if of value, is successful or not. Furthermore, considering emotions influence motivation and concentration from this perspective, it appears emotions influence students before, during and after engagement. So, as a potential incorporation of and response to Eccles' (2016) concern that researchers be explicit in their theorising regarding when emotions are evoked and when they are influential in learning engagement, from a CVTAE perspective, it appears that achievement emotions are influentially antecedent to engagement and are elicited both during achievement activities (learning engagement) and after either achievement or failure.

From Pekrun et al. (2017), the positive activating emotion associated with achievement activity (engagement) is enjoyment: 'Positive activating emotions (e.g., enjoyment of learning) are thought to preserve cognitive resources and focus attention on the learning task, support interest and intrinsic motivation, and facilitate deep learning' (p.1655). From this statement, it appears that engagement is associated with interest as well as enjoyment. Supporting the role interest plays in engagement, individual interest in a subject has been found to predict self-regulation, and in concert with self-regulation, interest predicts achievement (Lee, Lee, & Bong, 2014).

#### The role of cognition or mental processing in a definition of engagement

Multiple researchers have found that increased cognitive engagement of students improves academic outcomes. For example, Hu, Jia, Plucker, and Shan (2016) found in a longitudinal study that Chinese primary students who were taught critical thinking skills outperformed matched peers in both short and long term assessments. Goos et al. (2002) found that senior secondary school mathematics students were more successful at problem solving if they critically engaged others and focussed on evaluating the effectiveness of strategies. In agreement with the tripartite view of school engagement (Fredricks et al., 2004) it would seem that mental processing aimed at achieving learning goals should be included in a definition of learning activity engagement.

For clarity, in this study of mathematics engagement at the learning activity level, the term 'cognitive engagement' has been restricted to that related to thinking (defined here encompassed by the term 'mental processing'), namely the following: remembering, understanding, applying, analysing, evaluating, creating (Krathwohl, 2002); problem-solving, reasoning (Australian Curriculum Assessment and Reporting Authority, n.d.-b), cognitively connecting (Hattie et al., 2017; Quartz & Sejnowski, 1997), and estimating (Steen, 1999) — not attitudinal dimensions.

#### Grain size

It was helpful for me to refer to Skinner and Pitzer (2012) who differentiated engagement, and its opposite, disaffection, according to the size of the context: from the largest foci (prosocial institutions and communities), down to school, the classroom and lastly to learning activities. Sinatra et al. (2015) referred to this differentiation as the 'grain size' of the context and they include a level lower again — the within-individual level of engagement including physiological changes and eye-tracking as measures of engagement. Eccles (2016) has stated concern that researchers define the context and duration of their study on engagement clearly; making the grain size of the engagement context explicit would seem to assist in addressing this. Also, noting the grain size of engagement appears to be helpful in understanding measures of the context. For example, Fredricks (2011) has used school attendance and participation in extracurricular activities as measures of school engagement, but these measures are not to applicable to learning activity engagement.

**A definition of engagement from the literature**

Drawing on extensive research from multiple sources, Christenson et al. (2012) define engagement as the following:

> Student engagement refers to the student's active participation in academic and co-curricular or school-related activities, and commitment to educational goals and learning. Engaged students find learning meaningful and are invested in their learning and future. It is a multidimensional construct that consists of behavioral (including academic), cognitive, and affective subtypes. Student engagement drives learning; requires energy and effort; is affected by multiple contextual influences; and can be achieved for all learners (p. 817).

This definition has been useful to draw upon in this study, but it defines engagement as the driver of learning, not motivation, so would seem to cloud theorising and discussions regarding intrinsic and extrinsic motivation. This definition has not made the emotions associated with engagement explicit which would appear to be needed to help define and recognise the smaller grain size of learning activity engagement.

**A working definition of learning activity engagement**

As noted above, Fredricks et al. (2004) characterised engagement in terms of three 'classic' dimensions: behavioural, cognitive and emotional engagement. Gettinger and Walter (2012, p. 653) stated that engagement is the 'actual involvement or participation in learning' and Liem and Martin (2012, p. 3) and have defined engagement as the *behaviours* aligned with the 'energy and drive' (motivation) to learn. For Hannula (2006, p.165), motivation is 'structured through needs and goals'. Also, it seems positive learning engagement is associated with enjoyment and interest (Pekrun et al., 2007). Encapsulating many of these conceptualisations is the definition of engagement by Christenson et al. (2012) except that others have argued that motivation, rather than engagement, drives behaviour and learning.

For ease of referral and drawing from these mentioned sources, a working definition of learning activity engagement for this study was devised: 'Learning activity engagement is behaviour and mental processing directed towards achieving learning goals and is associated with enjoyment or interest'.

With this definition I sought to address both Eccles' (2016) concern that researchers make the context of the engagement they are studying clear and Boekaerts' (2016) issue with engagement needing to be conceptualised in terms of goals. That is, by defining the goal, the grain size and context of the engagement is clarified. For example, if the learning goal is for a class to produce an e-learning module on fractions, the engagement for that goal could be determined by the level of planning, conversations, creations, activity, questioning, strategizing and end achievement, or otherwise, of that goal. If the learning goal is for students to create an animation showing two different fractions concepts, then although similar determinants apply, the context is smaller and is for a different specific outcome.

This definition perhaps helps circumvent the criticism (Christenson et al., 2012) that observations in engagement research have tended to be construed differently if the dimensions of engagement are separated out and viewed as separate constructs (cognitive engagement, behavioural engagement or emotional engagement or some overlapping blend). For example, if a student raises her hand to answer a question about the links between two fractions concepts, that could either be recorded as behavioural engagement (raising the hand, complying with rules and speaking) or cognitive engagement (showing evidence of thinking about the question and possibly formulating an answer) or perhaps emotional engagement (showing interest in the question) or any combination thereof. But if the engagement focus is on the lesson's goal (for students to explore the links between fractions concepts) then the separation between behaviour, cognition and emotion is perhaps not necessary because the action, ostensible thinking and emotional involvement is directed towards the learning goal, so is deemed 'learning engagement' in that context. For a small study with one researcher, I made this decision to help focus my analyses. This meant I could still describe phenomena using separate constructs as necessary but determine learning engagement more holistically. Three further terms related to engagement need to be defined: disaffection, disengagement and compliant engagement.

**A working definition of disaffection**

In the field of education research, Skinner and Pitzer (2012, p. 24) stated that disaffection is simply the 'opposite of engagement' (as others have stated for disengagement; see below) then elaborated that disaffection is characterised by 'physical withdrawal of effort, such as lack of exertion, passivity, merely going through the motions, or exhaustion as well as their mental counterparts, such as lack of concentration, apathy, inattention, or amotivation' (p. 25). For these scholars, disaffection is characterised as operating at the learning activity level. Skinner and Pitzer stated that the emotional dimension of disaffection is important too because 'patterns of action differ depending on whether lack of participation is based on boredom, anxiety, shame, sadness, or frustration' (p.25). Pekrun (2006) identified two negative emotions involved in active learning: boredom (low arousal) and frustration (high arousal). That seems to indicate that, using Pekrun's findings, boredom and frustration would be the main emotions associated with disaffection.

In regard to secondary mathematics education, Nardi and Steward (2003, p. 346) stated that student disaffection involves 'low engagement with learning tasks' and perceiving these tasks as irrelevant to the world outside school and unconnected to their own needs and interests. Disaffection is manifest when students tend to 'routinely execute but do not get substantially involved with the task' (p. 346). So, for Nardi and Stewart, disaffection seems to be associated with a lack of interest.

The working definition of learning activity disaffection offered for the purposes of this study, and the counterpart of the working definition for engagement described above, is the following: ‘Learning activity disaffection is characterised by the lack of committed action or mental processing directed towards achieving learning goals and is associated with boredom, frustration or a lack of interest’.

**A working definition of learning activity disengagement**

According to the Macquarie dictionary online (2019) to disengage means ‘to release from attachment or connection’. In the literature, disengagement has been described as the opposite of engagement and is associated with a rather intractable, longer-term separation from or avoidance of learning (e.g., Martin et al., 2012; Wilson & Mack, 2014), particularly of a specific subject, especially, unfortunately, mathematics. For a simple and useful definition in regards to middle school students’ mathematics education, Martin et al. (2012, p. 2) stated that mathematics disengagement is ‘switching off’ from the subject. Elsewhere, school disengagement is discussed in terms of students dropping out from school (Balfanz, Herzog, & Mac Iver, 2007).

In the context of learning activities, disengagement would seem to relate to a detachment and disconnection from a specific learning activity. The specific emotions associated with learning activity disengagement (as defined here) have been harder to locate. Pekrun et al. (2017) found in a longitudinal study that negative achievement emotions (anger, anxiety, shame, boredom, hopelessness) negatively predicted achievement, so it would seem logical, but is not explicitly known, that these emotions could also be associated with much shorter term learning activity disengagement where students switch off from learning and therefore not achieving a learning goal. As such, the caveat ‘feasibly’ is attached to the negative emotions elicited by or associated with learning activity disengagement in the definition below.

The following working definition of disengagement is proposed: ‘Learning activity disengagement is switching off from a learning activity with no action or mental processing directed towards achieving the learning goal and is feasibly associated with negative achievement emotions: boredom, anxiety, anger, shame and disappointment'.

This definition, describing *no* engagement, is contrasted with that of disaffection which describes *low* or *minimal* engagement. It is proposed that learning activity disaffection is more proximal to the learning goal than disengagement.

**Defining compliant engagement**

Compliant engagement (see Crick, 2012) is differentiated somewhat from disaffection and describes behaviour which might appear to be directed towards a learning goal, but it is actually directed towards complying with social norms, not learning. It is unlikely to be associated with apparent enjoyment or interest. Similarly, it is proposed here that other behaviour that is directed towards another goal (other than learning), like ego protection or socialising, names the goal explicitly, for example, engaged in ego protection or engaged in socialising (noting in the latter case, writing 'social engagement' might be confusing).

Compliant engagement may seem to align with what Nardi and Stewart (2003) characterised as quiet disaffection, but perhaps quiet disaffection is still disaffection — with the focus not on learning and the feeling of boredom or frustration is indeed evoked, but the overt expression of it suppressed — and in compliant engagement the student focuses on pleasing the teacher. Comparing disaffection and compliant engagement, the deciding factors would seem to be the emotions evoked and degree of volition involved. That is, if students are not willingly doing the tasks and are bored or frustrated, 'disaffection' would be characterised. If students are doing the tasks, but without conviction and without particularly experiencing boredom or frustration, it would be described as 'compliant engagement'.

## 4.4 Two Theories of Engagement

According to Watt and Goos (2017), there are currently three major theories used to explain and predict students' actions, feelings and thoughts relating to engagement in mathematics education: expectancy value theory, EVT (Eccles et al., 1983); achievement goal theory (Dweck & Elliott, 1983); and self-determination theory, SDT (Ryan & Deci, 2000). Achievement goal theory was discussed briefly, in Chapter 3: Influences on Engagement, as explaining students' pre-existing tendencies to adopt approaches and strategies towards, or away from, learning goals. In this section I discuss EVT and SDT. Expectancy value theory is used in this study to explain the decision-making processes resulting in engagement or disengagement for students at the learning activity level and self-determination theory (SDT) is used to explain the needs which needed to be supported for the students for students to maintain engagement.

**Expectancy value theory**

Expectancy value theory (EVT) holds that individuals' self-motivated engagement in an activity is determined by the costs and benefits that they associate with that task and their prediction of likely success (Eccles et al., 1983). This theory aligns with, and can be used to describe, self-regulated learning which involves students' ability to plan and manage their own learning and select cognitive learning aids (Pintrich & De Groot, 1990). As described by Pintrich and De Groot (1990), there are three motivational components for students: their expectancy to be able to successfully complete the task; their valuing of the task; and their emotional reaction to and interest in the task.

Underlying the choices made by students at the activity level, within an EVT perspective, there are a raft of other interrelated social-cognitive factors bearing on their decision to engage or not (Wigfield & Eccles, 2000). These factors include the following: the social milieu in which the task is presented (gender roles and activity stereotypes); how the individual generally views his or her degree of internal agency and ability to shape events (internal locus of control) or whether he/she feels manipulated by others and external events (external locus of control); the student's affective memories of similar events built from previous achievement-related experiences; and interactions with others and their reactions (Eccles et al., 1983). These factors were drawn on to help form the first or pre-phase of the theoretical framework of this study.

Expectancy value theory has been used in a wide variety of research endeavours, particularly in evaluating pedagogies and sorting out competing drivers. For example, Fielding-Wells et al. (2017) assessed the efficacy of inquiry-based learning tasks in primary mathematics classes by examining student responses to subjective questions and video tapes of classroom work for evidence of energy, concentration and self-regulated action. As another example, Lauermann, Tsai, and Eccles (2017) used EVT to extricate and explore students' motivations, decisions and decision-making processes in whether to choose mathematics-related careers or not.

Expectancy value theory was useful in this study in informing the design of the activities for lower secondary school students. Subjected to transition into the generally less emotionally secure environment of secondary college compared to primary school, lower secondary school students can be prone to constant social comparisons and the unmet need to belong (Eccles et al., 1993). This suggests that putting participants where they are required to publicly choose activities which they might perceive others could disfavour (or openly do disfavour) needs to be avoided, even if the individual is interested in that activity, because perceived social pressures are likely to tip the cost-benefit balance towards non-participation. For example, student participants might appreciate completing written evaluations of activities post-completion discreetly and anonymously and not being asked to state their anticipated involvement in front of the class.

The theoretical framework of this study focusses on the subjective task value and expectancy of success aspects of EVT to show the two pathways that students choose, engagement or otherwise, when presented with a learning task. However, as reviewed by Stroet et al. (2013), multiple studies have shown that the psychological needs of early adolescent students are also important in establishing their engagement or otherwise in their studies, and so to work in concert with EVT, I turn to self-determination theory to help frame the theoretical basis of this study.

**Self-determination theory**

Deci and Ryan's (1985; 2000) self-determination theory (SDT) holds that humans have three innate psychological needs: autonomy, relatedness and competence. Therefore, for learning contexts to be psychologically safe and free from interference by unsatisfied psychological needs, each of these needs must be satisfied within the pedagogy. Deci and Ryan theorised that psychological motivations are either volitional and self-determined or controlled externally. ‘When a behavior is self-determined, the regulatory process is choice, but when it is controlled, the regulatory process is compliance (or in some cases defiance)’ (Deci et al., 1991, p. 327). When behaviour is externally controlled with threats of punishment (adverse consequences) or promises of rewards, this undermines the development of intrinsic motivation (Deci et al., 1999).

Various scholars in the literature have conceptualised that the need for autonomy can be satisfied by giving students meaningful, relevant choices where the utility of the learning is explicit (Assor & Kaplan, 2001; Balfanz et al., 2007; Hulleman et al., 2010; Jang, Reeve, & Deci, 2010). The need for connectedness, which also resonates with sociocultural learning theories (Goos, 2014; Vygotsky, 1986), can be satisfied by giving students the opportunity to work and interact in their learning with others (Bennett, 2014; Goos, 2014; Hand, 2010). The need for a sense of competence, or self-efficacy, has been supported by multiple theorists and studies (Bandura, 1991; Carroll et al., 2009; Dweck, 2002; Dweck & Master, 2009; Jang et al., 2010; Pajares, 1996; Schunk, 1991; Skinner & Belmont, 1993; Wigfield & Eccles, 2000). Self-efficacy can be gained by giving students the opportunity to experience or at least work towards mastery with clear instructions, guidance, and honest, but supportive, feedback (Stroet et al., 2013).

In a systematic review, Stroet et al. (2013) found that ‘need supportive teaching’ (supporting students’ SDT-oriented psychological needs for autonomy, social involvement and competence) improved motivation and engagement, but satisfying just one of these needs had little or no effect. This finding resonates with Deci and Ryan who stated ‘psychological health requires satisfaction of all three needs; one or two are not enough’ (2000, p. 229).

In the context of mathematics education, Watt and Goos (2017) surmised that both of the motivation theories mentioned, expectancy value theory and self-determination theory, appear not to be in competition with each other, but highlight in a complementary way different aspects of a trajectory towards a learning goal within a classroom: decision-making (EVT), and the psychological needs which underpin motivation (SDT).

### 4.5 Theoretical Framework

The theoretical framework used in this study is intended to highlight what appear to be plausible, visualised links between the three previously described theories, which have been widely drawn on in education research: expectancy value theory (EVT) (Wigfield & Eccles, 2000), self-determination theory (SDT) (Deci & Ryan, 2000) and the control value theory of achievement emotions (CVTAE) (Pekrun, 2006). The framework shows a proposed transitive, temporal relationship: presenting of the learning activity → motivation → engagement → learning goal. Pathways show when disaffection and disengagement are thought to occur. As with Martin's (2007a) Motivation and Engagement Wheel, which references multiple theories impacting motivation and engagement, positive influences are depicted on the top and negative influences on learning engagement are on the bottom.

The framework, presented in Figure 4.1, displays three phases of learning activity engagement:

(a) the existing psychological and social climate, pedagogy and individual receptivity which may influence the student before, during and after the learning task is presented (please refer to the green and brown boxes at the left of Figure 4.1); please see Chapter 3: Influences on Engagement for explanations of these factors;

(b) the presentation of the learning task (please see the orange box in Figure 4.1) and EVT-mediated decision of the individual student to engage or not (please refer to the pink arrowed box and the trajectories leading from it in Figure 4.1); and

(c) the motivation and engagement phase which either supports the students' needs (SDT) and continues to foster intrinsic motivation or otherwise (please refer to the green arrowed boxes

'Motivation' and 'Engagement', and the elements showing either positive or negative emotions associated with engagement or disaffection respectively in Figure 4.1).

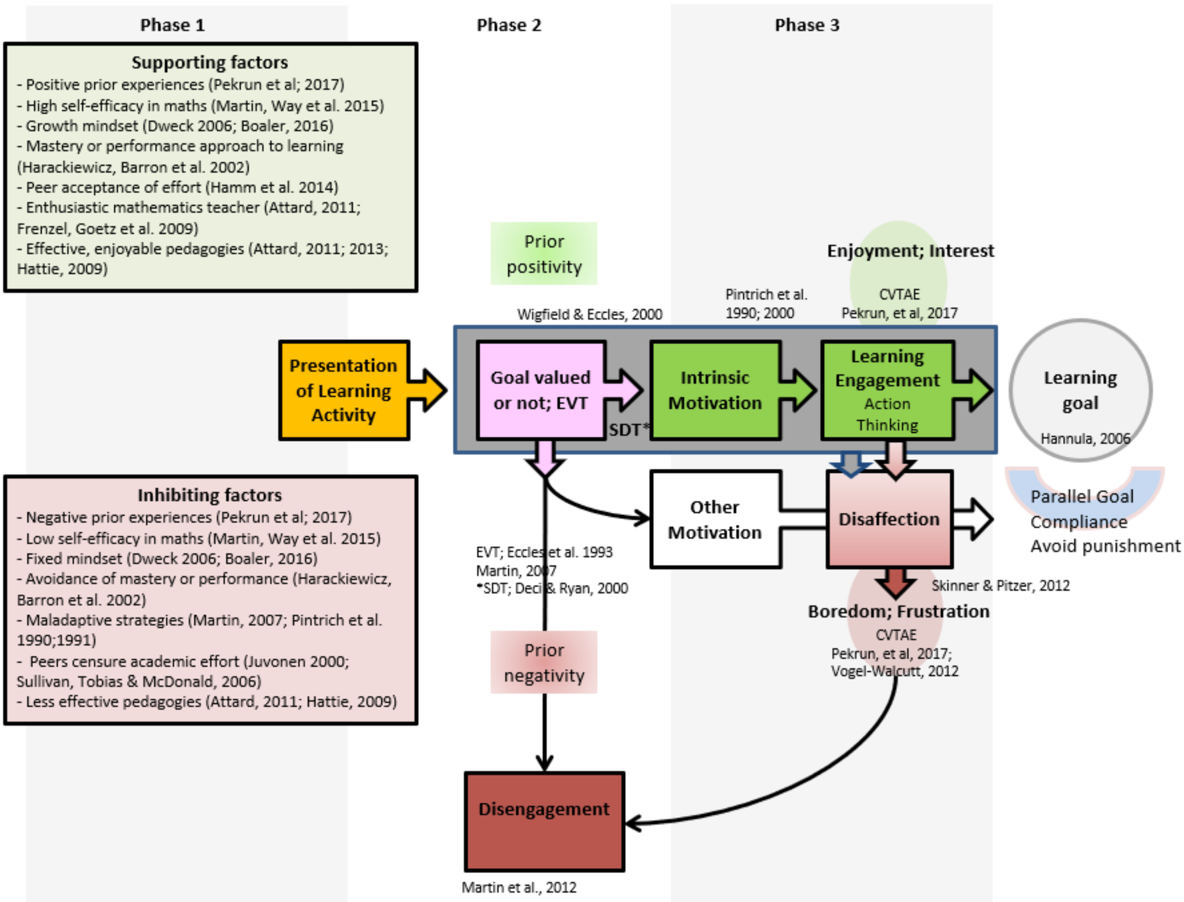



*Figure 4.1.* Theoretical framework showing engagement trajectories and proposed links between expectancy value theory (EVT), self-determination theory (SDT), and the control value theory of achievement emotions (CVTAE)

### First phase — Influences and prior effects on engagement

Before a learning task is presented within a mathematics classroom, an array of researched factors has been found to influence motivation and its successor, engagement. Please refer back to Chapter 3: Influences on Engagement for discussion of these factors. The first phase of the theoretical framework for this study highlights this complex mix of prior or existing factors which may either be conducive to engagement or have a negative effect. These factors might also have ongoing influences throughout learning and engagement in the activity.

The scope of the factors outlined here has been limited to those which can conceivably be altered or act directly within a classroom, so societal, curriculum and parental effects are not discussed. The study was also delimited to not include background information on the students, like ethnicity and socioeconomic status, so these factors and any attitudes regarding them are also not discussed here. In this study, students were invited to, and for the most chose to, make their written responses anonymously, so the identity, and therefore gender, of much of the students' responses is not known, so gender and attitudes regarding gender are also not discussed here.

The following factors affecting early adolescent students' engagement in mathematics from Chapter 3: Influences on Engagement are listed here:

(a) past emotional experiences in learning (Pekrun et al., 2017);

(b) longer-term affective states (beliefs, values and attitudes) regarding mathematics (Attard, 2011a; Attard et al., 2016; Grootenboer & Marshman, 2016);

(c) self-efficacy, self-regulation, planning and task management in mathematics (Bandura & Schunk, 1981; Bjork et al., 2013; Eccles & Wigfield, 2002; Martin et al., 2015);

(d) other social-cognitive factors (mindset, goal-orientation and strategies) (Dweck, 2006; Elliot, 2005; Pintrich, 2000; Pintrich & De Groot, 1990);

(e) maladaptive strategies or states (avoidance, procrastination, self-sabotage, longer-term disengagement, longer-term anxiety, failure avoidance) (see Martin, 2007a);

(f) early adolescent peer and social influences (Hamm et al., 2014; Juvonen, 2000; Sullivan, Tobias, et al., 2006);

(g) perceived level enjoyment in the mathematics classroom (Martin et al., 2012);

(h) teacher influences (Attard, 2013; Frenzel et al., 2009);

(i) effective pedagogies (Attard, 2011a; Hattie, 2012); and

(j) the physical environment (Hines, 2004; Woolner et al., 2007).

It is neither possible nor is it within the remit of the research question of this study to measure of all these and more factors as potentially affecting a mathematics class of Year 8 students. However, suffice to state that there is a complex array of psychological, social, socio-cognitive, pedagogical and physical factors bearing on the engagement of early adolescent individuals in a mathematics classroom. It appears these factors might work together or compete to have either a favourable, neutral or adverse effect on engagement on each individual when students are presented with a learning task. With the influences acting within that background outlined, the next phase of this study's theoretical framework occurs at the presentation of the learning task.

**Second phase — Deciding**

The second phase is the presentation of the learning task to the students whereby, as described by expectancy value theory (EVT), learners make judgements about the activity depending on their appraisal of their individual ability to complete the learning goal, their valuing of the goal (including its perceived relevance to the learner) and the costs and benefits of engaging. As described in section 4.4 Two Theories of Engagement under the sub-section on EVT, if the assessment is positive, a learner is more likely to engage; if the subjective assessment is negative, the learner is likely to not engage in the lesson (Eccles et al., 1983; Wigfield & Eccles, 2000).

***Maladaptive strategies.*** Maladaptive strategies (avoidance, procrastination, self-sabotage) (Martin et al., 2003) would perhaps tend to operate at the time of the presentation of the task and, depending on the strength of the pull away from the learning task, lead to disengagement or disaffection. Adaptive, effective strategies would perhaps tend to have most influence during engagement.

**Third phase — Engagement**

The third phase is during execution of the learning activity. Once students have decided to engage in the activity, they either keep working towards the learning goal, or they do not. Students might be willing to start an activity, but find that they are failing, or that there is little opportunity to interact with others or there are too few choices, that is, as described by self-determination theory (SDT), the students may not have their psychological needs for competency, relatedness and autonomy met (Deci et al., 1991). If students are expressing boredom or frustration (Pekrun, 2006), they would appear to be disaffected and would need extrinsic motivators, rewards, punishments (Deci & Ryan, 2000) or the compunction of obligation (Crick, 2012), to complete the task (please refer to Figure 4.1 noting the white arrowed box denoting other motivations and engagement directed towards other parallel goals including compliance and avoiding punishment). Conversely, as described in the section on SDT, it is during this phase that students who are intrinsically engaged in the activity, that is, have their psychological needs for autonomy, relating to others and for competency met (Deci & Ryan, 2000) while working towards to learning goals, and will likely be feeling and perhaps expressing enjoyment or interest or both (Pekrun et al., 2017).

***Effective strategies.*** Effective strategies (planning, persisting, rehearsal, elaboration and use of organisational aids) have been found to help students engage in and achieve learning goals (Berger & Karabenick, 2011; Pintrich, 2000; Pintrich & De Groot, 1990). Berger found a unilateral relationship with effective strategies and learning engagement. That is, having adaptive strategies helps students engage and achieve, but engaging and achieving does not influence employment of effective strategies. This seems to imply that effective strategies need to be taught. I am not certain whether this directional finding contrasts with or helps validate the finding by Pekrun et al. (2017) that positive emotions accompany effective strategies, but regardless, effective strategies seem to help set up for positive engagement in learning.

### The theoretical framework — A concluding note

It has been helpful in this study for me to discuss and see the potential links between three theories on which the model draws, EVT, SDT and CVTAE, and to organise factors according to when they appear to shape learning activity engagement — either before the presentation of the task (and potentially throughout the learning activity), during the presentation and decision making phase of the task or whilst the learning engagement is unfolding. I have also been struck by the complexity and apparent tenuousness of engagement and how many factors need to be aligned to support students engaging in an activity.

## 4.6 Concluding this Chapter

In this study, I explore engagement, and its corollary opposites, disaffection and disengagement, at the learning activity level. Engagement at the activity level is conceptualised in this study as intrinsically motivated actions and thinking directed towards a learning goal and is associated with and, in part, identified by, positive, activating learning activity emotions: enjoyment and interest. Disaffection, the opposite of engagement, is conceptualised here as a lack of committed actions and thinking directed towards a learning goal and is associated with apathy and the negative emotions of boredom (deactivating) and frustration (activating). Disengagement, more distal from the learning goal than disaffection, is defined here as a switching off from a learning activity with no actions or thinking directed towards achieving a learning goal. It seems feasible that a range of negative emotions might be associated with learning activity disengagement (no engagement) but the theorising on the expected emotions elicited at this grain size, for this construct, does not yet seem to be characterizable. Compliant engagement describes a rather de-energised involvement in learning activities with the goal to comply with social norms rather than the intrinsically motivated drive to achieve the learning goal.

The theoretical framework for this study shows how expectancy value theory and self-determination theory appear to work in concert to explain student engagement and how the control value theory of achievement emotions seems to tie in with these other theories. Some of the multiple antecedent and ongoing influences on early adolescent students' learning engagement in the mathematics classroom, many of which are identified within the broader theorising of expectancy value theory, include the following: (a) past emotional experiences and attitudes, values and beliefs in learning mathematics; (b) social-cognitive factors and strategies; (c) social and peer influences; (d) teacher and pedagogy; and (e) the physical environment.

In the following chapter, I describe how data was obtained and analysed to answer the research question and I show the philosophy, methodology, methods and setting of this study.

# Chapter 5: Research Philosophy, Methodology and Methods

In this study, I explored engagement and disaffection at the learning activity level of a class of Year 8 students while they created and appraised digital media and other elements for an e-learning module in fractions. The impetus for this study was to gain insights into widespread reported disengagement in mathematics, particularly amongst early adolescents (Attard, 2013; Martin et al., 2012), which I too had witnessed when teaching. The research focus was both practical and theoretical. The data gathered were designed answer the research questions: 'What activities, activity characteristics and conditions seem to be engaging for these Year 8 mathematics students while co-creating an e-learning module on fractions?' and 'What activities, activity characteristics and conditions seem to be boring, or otherwise disaffecting or disengaging, for these Year 8 mathematics students while co-creating an e-learning module on fractions?' To understand the practicalities of engagement at the activity level, I needed to understand the influences on engagement and the extant theories used to explain engagement itself. A theoretical framework was devised to help me characterise engagement, disaffection and disengagement at the learning engagement level, to recognise these constructs in the data and to interpret the results.

Initially, this study was planned to focus on the larger group-goal of creating an e-learning module, however, as outlined in the thesis introduction, the e-learning module was not completed and did not seem to be the unifying, engaging, relevance-creating goal I had initially anticipated. So, the research focus shifted to the learning activities within the project and the methods and instruments used were adjusted or devised according to this new goal. In focussing on the engagement value of an activity, if students appeared to find it disaffecting or not at all engaging, I wanted to try to understand why. Similarly, if students found an activity engaging, I wanted to try to understand what was engaging for them.

## 5.1 Signposting this Chapter

In this chapter, I describe the methodology for the study's design and the methods used to answer the research question.

In section 5.2 The Research Paradigm, I outline my previous epistemological approach to all research, stemming from my personal background, which needed to be challenged and addressed before I could undertake this qualitative study. I explain the research paradigm chosen, my newly embraced epistemological assumptions, my interpretive, pragmatic approach taken towards the study and the methodological stance I have taken.

In section 5.3 'Why qualitative research?', I clarify why a qualitative study was required.

In section 5.4 'Why a case study?' I show why an explorative case study design was chosen to best answer the research question and the study's objectives.

In section 5.5 Addressing Issues of Validity, I explain the approaches used to address issues of rigour and validity (credibility, trustworthiness, transferability and confirmability).

In section 5.6 Setting, Timeframe and Participants, I outline the setting for and participants within the study and show a table of the planned lesson sequence and fractions concepts covered.

In section 5.7 Ethical Considerations, the ethical aspects of the study are described.

In section 5.8 Methods, the methods used in this study to obtain data, including the equipment and instruments used and how the data were analysed, are described as well as a rationale for their selection. Although mostly standard approaches and methods were adopted, I describe and justify approaches that were devised particularly for this study.

## 5.2 The Research Paradigm

Personally, coming from a biomedical background involved in quantitative research, questions about the philosophical background of a study at first seemed foreign, confusing and unnecessary for me. That was an ignorant starting point. However, I came to realise that whereas the discipline of quantitative studies I had been involved in came from controlling variables, the discipline of this qualitative study involved *not* controlling them but allowing the participants' voices to be heard and attempting to understand them. Although observer bias is well documented in quantitative studies (e.g., see Landis & Koch, 1977), I further came to value that any attempt I made to observe or interpret behaviour was necessarily coloured by my own subjective viewpoint, experiences and social interactions, and that all the participants in the study would have the same issue, although mine was more formalised in that I needed to record my interpretations for the purpose of writing and conveying findings.

In this qualitative study, I embraced the belief that there are multiple realities in that each person constructs and interprets reality from their own experiences and influences (Creswell, 2013), and as such, the study required evidence from multiple perspectives from all the participants, including myself. This belief entails that a researcher explores, acknowledges and declares the socially and experientially constructed nature of what he/she calls reality (Yin, 2016). Thus, I needed to construct the study to minimise the influence of my own reality on those of the other participants and actively 'step out of the way' of the expressed realities of others. This was planned to be facilitated by (a) including open-ended questions in the questionnaires; (b) asking open-ended questions during interviews; (c) using the participants' actual words in reporting their responses; (d) including the option of anonymous responses for the students; and (e) by recording video evidence of events (Creswell, 2013). I used thick, detailed descriptions of events with the objective to improve both the representativeness and humanness of the recorded observations and to bring the subjects' voices and experiences to life for the reader (Geertz, 2000; Wolcott, 2008).

The interpretive framework was strongly based on pragmatism (Creswell, 2013; Yin, 2016), that is, while acknowledging multiple realities, I concentrated on what approaches seemed to be working in gathering useful data (Yin, 2016). Responding to the conditions and outcomes in the study as it proceeded, I adjusted and trialled various approaches and activities to see what worked. However, what I had deemed was working or otherwise was in itself an acknowledged interpretation.

This study was conducted 'in the field' of a working Year 8 mathematics classroom (Yin, 2016). Unavoidably, the study created a degree of artifice in that it is not usual to have a researcher in the classroom conducting the class for nine lessons and conducting testing (questionnaire, pre- and post-tests and focus group) for a further four sessions. Nonetheless, the combined subjective evidence of all the participants — teacher, students and researcher — was used to form a picture of what happened, what was experienced during the exploration, what appeared to work in terms of student engagement at the learning activity level and what did not. Where possible, as mentioned above, verbatim quotes from the participants were used to illustrate their experiences.

### 5.3 Why qualitative research?

According to Creswell (2013), qualitative research is useful when a 'problem or issue needs to be *explored*' (p. 47; italics in original). In this study, engagement of the students is explored at the learning activity level in mathematics. A qualitative exploration rather than a hypothesis-driven quantitative study seemed warranted because, as the review of the literature has revealed, the concept of engagement itself, especially at the learning activity level, does not yet appear to have been firmly characterised (Boekaerts, 2016; Christenson et al., 2012; Eccles, 2016), the problem of early adolescents disengaging from their studies of mathematics is still widespread (Martin et al., 2015; Watt, Carmichael, & Callingham, 2017; Wilson & Mack, 2014) and the use of student-generated digital media as a pedagogical approach in secondary schools seems largely unreported in the literature (Henderson et al., 2010). Furthermore, in this complex arena, I was keen to not only document what was happening but how the activities were experienced from multiple perspectives. So, in this qualitative study, the voice of the students was sought (see Attard, 2011a; Nutbrown & Clough, 2009; Scanlon, 2012; Wilkie & Sullivan, 2018) as well as that of their teacher and the researcher/presenter (me). These perspectives, where feasible, could then be compared with that captured through the lens of a video camera.

Qualitative research has been reported to be useful when subtle or complex elements, or interactions, need to be studied in depth; potential markers identified; the context of the problem ascertained; or a theory or testable hypothesis developed for a later quantitative study (Ary, Cheser Jacobs, Sorensen, & Walker, 2014; Creswell, 2013; Creswell & Miller, 2000). In this study, engagement and disaffection were characterised and explored at the activity level, and drawing on the control value theory of achievement emotions (CVTAE; Pekrun, 2006), the emotions of enjoyment and boredom were explored as potential respective markers for engagement and disaffection (with ostensible complex caveats, especially for the latter).

### 5.4 Why a case study?

Case study research occurs in a contemporary, real-life setting (Yin, 2016) and follows a bounded system (the case) involving the collection of multiple sets of data from multiple sources over time (Creswell, 2013). The defining features of a case study are that a specific case is identified, and it is described and studied in-depth such that themes or issues are uncovered. The purpose of a case study is to bring the inherent themes to light and to build patterns and learn lessons from doing so (Creswell, 2013). In this exploratory instrumental case study, I wanted to examine engagement and disaffection at the learning activity level in depth with a mathematics class of Year 8 students and their teacher in situ over multiple lessons using multiple sources of information. So, a case study methodology was deemed an appropriate fit for the purposes of this study.

The ‘case’ here was designated as the mathematics class of Year 8 students, their teacher and me, as the researcher/presenter, when working on a project: co-creating an e-learning module on fractions. The learning sequence and its activities bounded the case. The students, the teacher and I were the participants of this case. Unlike an intrinsic case study where the case is intentionally selected for its uniqueness or representativeness, in this exploratory, instrumental case study, the intent was to understand a sector of a larger problem (Creswell, 2013), disengagement of lower secondary students in mathematics, in this case, by looking at the activity level of engagement and disaffection in a class of Year 8 students co-creating an e-learning module on fractions.

There seem to be differing views about the worth and justification of qualitative studies with some theorists seeming to value qualitative inquiry only in relation to quantitative research and others finding that such an approach misses the point and value of it. According to Willis (2008, p. 219), an advocate of qualitative studies, case studies can be seen by positivists as the 'brush clearer that goes into rough and unexplored wilds to clean things up enough so that real research can be conducted'. Flyvbjerg (2006) has countered positivist evaluations by stating is that randomly selected cases and multiple case studies can indeed be representative. However, Willis questions, 'Why not emphasize that case studies provide us with experiential knowledge and add to the general, phronetic, foundation of understanding upon which we make our professional decisions?' (p. 219-220). In this case study, I wanted to gather the experiential knowledge of the students, the teacher and the researcher/presenter and to explore the practical utility, or otherwise, of the various activities offered to the students. Furthermore, as posited by Yates (2003), the methodological warrant of qualitative studies with a small sample size 'has to be constructed by the researchers in ongoing and multiple acts of design, comparison, dialogue, reflexive critique and interpretation' and not by, almost apologetically, emphasising data treatment techniques that attempt to mimic factor analysis (p. 224). Throughout this case study, I questioned and exposed my assumptions, and the trajectory and content of the learning sequence were adjusted according to reflexive analyses and discussions with the teacher on what appeared to be engaging, or otherwise, for the students. The data evaluations were interpretations of the most salient patterns seen in the results and honest attempts to represent participants' experiences with their verbatim accounts, reactions, observations and reflections; the study was not hypothesis-driven so statistical analyses were not applicable or warranted.

From this single case study, my aim could not validly be to make generalisations, but I hoped that from this exploration, further research might be indicated which might be generalisable (Creswell & Miller, 2000; Yates, 2003).

## 5.5 Addressing Issues of Validity

According to Miles, Huberman, and Saldana (2014), 'validity is a contested term among selected qualitative researchers' (p. 313) because some see it as untenably aligning with and borrowing a term from quantitative research, whereas others prefer to use the word to retain a sense of rigour also necessary for qualitative research. Regardless of these conflicting viewpoints, Miles et al. (2014) argue that there seems to be general consensus that qualitative researchers make strategic effort to give readers confidence in the conclusions drawn by demonstrating what might be variously called validity or authenticity or credibility. I embraced the word validity as a succinct term encompassing issues of legitimacy, clarity, truthfulness and rigour. Here, the issue of validity is discussed and addressed under the headings of the credibility, trustworthiness, transferability and confirmability practices (Ary et al., 2014; Guba & Lincoln, 1994).

### Credibility

Credibility or 'truth value' (Ary et al., 2014, p. 531) of the findings was addressed using a range of strategies including the following: employing multiple data collection methods and data and methods triangulation (Miles et al., 2014); using low-inference descriptors (Johnson, 1997); theoretical adequacy (Ary et al., 2014); and reflexivity (Johnson, 1997; Yin, 2014).

***Data and method triangulation*.** In this study, data and methods triangulation (Miles et al., 2014) was planned to be achieved by using multiple data sources and methods (Creswell, 2013) to corroborate findings: (a) students' written responses to exit slip and questionnaire prompts; (b) teacher interview data; (c) researcher journaling; (d) student-produced artefacts; (e) student responses to a focus group discussion; and (f) video documentation of the lessons. Please see below in section 5.8 Methods for details on the methods used.

***Low inference descriptors.*** In this study, direct quotations of the participants' words were used to demonstrate their experience. The written and oral responses from these Year 8 students were found to be very brief, so the rich, thick descriptions from the student participants (Geertz, 2000; Wolcott, 2008) were anticipated but not forthcoming in this particular study. Interview data from the teacher and researcher (my) journaling afforded rich, thick descriptions as did the interpreted descriptions from the classroom videos.

A further point about the low inference descriptors used in this study is that all of the raw written data from the students were brief, so all of it and the themes attributed to each response is made available to the reader in appendices. I conferred with senior colleagues (supervisors) throughout the data analysis process to aid in making valid interpretations of patterns and selecting representative quotes.

***Theoretical adequacy.*** In this study, a theoretical framework (Miles et al., 2014), based on self-determination theory, expectancy value theory and the control value theory of achievement emotions, was developed to help explain findings. Each pattern of findings discussed was considered in the light of the framework which, in turn, was considered to provide theory triangulation of the findings.

***Reflexivity.*** In this study, I actively sought sources of researcher bias (Yin, 2014) and took steps to address them by openly disclosing my researcher assumptions and allowing the findings to challenge them.

### Trustworthiness

As a strategy to demonstrate trustworthiness or dependability of this study, I ensured the findings were trackable (Ary et al., 2014; Guba & Lincoln, 1994). I documented how the study was conducted and explained the decisions I made. I show the timestamping of recorded data and, in the appendices, give access to the reader to the full range of students' written responses, colour-coded by theme for easier interpretation and, for the exit slip data, in ascending order of both self-rated engagement and learning level.

**Transferability**

In keeping with the purposes of an exploratory study in general, in this exploratory study I sought to identify elements which had the potential to be further investigated with research in other contexts (Miles et al., 2014). Also, measures were undertaken to strengthen validity in this regard by providing rich, thick descriptions of the context such that the reader may be able to consider the applicability to their own context.

**Confirmability**

In this study, as a strategy to demonstrate the confirmability of the findings, I documented each of the research methods used in detail (Miles et al., 2014). For example, I showed the exit slips used and the changes made to them during the course of the study. I documented when they were administered. I show how the responses were analysed for themes and colour-coded by theme so that comparisons could be made within and across lessons and that links to specific activities could be drawn. I explain how anonymous responses were treated and how the within-study labelling was implemented.

## 5.6 Setting, Time Frame and Participants

In this section, I describe the setting and the time frame of this study, and I introduce the participants.

**Setting**

A public (government) secondary school was chosen, which had at least two Year 8 classes and was within feasible commuting distance (< 1.5 hours driving duration) for the researcher. The class chosen needed to have an expert mathematics teacher to help guide the pedagogy of the study. Rivertown High School was selected. It is a small inner regional school in Victoria, Australia. According to MySchool website information (Australian Curriculum Assessment and Reporting Authority, 2017), with numbers rounded to maintain anonymity of the school, at the time of the study in 2017 it had approximately 380 students, 35 full-time equivalent teaching staff and the school community had a moderately low Index of Community Socio-Educational Advantage (ICSEA) of between 950 and 960 (the Australian average is 1000 with a standard deviation of 100).

The principal of the school was contacted first and asked if the research might be permitted and of benefit. I needed to know if there were at least two Year 8 classes in the school and an expert teacher was available and willing to have the research conducted in his or her Year 8 mathematics class. The criteria were met, and the principal and the teacher agreed.

The lesson sequence for the study was allocated one of the weekly timetabled mathematics lessons: last period each Friday — the latter not by my choice. All lessons in the sequence were conducted within the school's one computer room (which the teacher helpfully booked for this study); the focus group discussion and pre-test were conducted in a regular classroom.

**Time frame**

Two months before the project started in the classroom, interviews and planning meetings with the expert teacher were conducted. The sequence was planned to last for 10 weeks (one lesson per week for one term) but continued for three additional lessons. Of the 13 sessions, ten lessons included learning activities with the aim of co-creating an e-learning module on fractions (for the duration of two school terms April 28, 2017 to July 21, 2017). In Lesson 10, the main questionnaire on students' responses to the learning activities was administered at the beginning of the session with some learning activities presented afterwards. Three sessions were for gathering specific data with no or few learning activities afterwards:

- Pre-test on fractions concepts [April 21] — Lesson 1
- Post-test on fractions concepts [July 28] — Lesson 12
- Focus group discussion [October 26] — Lesson 13.

Please see below the in section 5.8 Methods, sub-section 'Planning of lessons' for more details.

**Participants**

To study activity engagement within the broader context of lower secondary students' disengagement from mathematics, Year 8 rather than Year 7 students were selected for this study. It was considered that participation in this study may have added further disruption to Year 7 students during their transition to secondary school, and this might have affected the study's findings. The classroom teacher needed to be an expert teacher in mathematics because the study required pedagogical collaboration from the teacher involved. I had initially envisioned that the class teacher would teach the (provided) lesson sequence and that I would make observations and collect data, but she expressed her reservations about her role. The teacher was very experienced (with three decades of teaching experience including highly skilled teaching with computer algebra system [CAS] graphing calculators and using web-based school software) but was not familiar with teaching with student-generated digital media. Conversely, I had conducted multiple projects with both primary and secondary students using stop-motion animation (including lunchtime projects for reluctant learners). I subsequently conducted the lessons (and so I refer to myself as the researcher/presenter throughout the rest of this thesis).

The expert mathematics teacher at the school involved in this project is referred to as Serena, which is not her real name. Where the identity of the students is known, they are referred to by pseudonyms chosen to match the gender of the student, but nothing else. The name of the inner regional Victorian town from which the secondary school is situated is referred to as Rivertown, which is not its real name. There were 19 students in the class, and 17 agreed to participate in the study. The other two students, who withdrew after initially being open to participate, remained in the classroom and were given mathematics work to complete by their teacher, Serena. They were asked to sit in an area behind the study's classroom video camera so that their images would not be captured.

### 5.7 Ethical Considerations

Ethics approval was sought and granted from both the Monash University Human Research Ethics Committee and the Victorian Department of Education and Early Childhood Development before approach was made to the principal of Rivertown High School . Once the principal and

Serena approved the study, explanatory statements and consent forms were issued to parents to consider for their children and explanatory statements and assent forms were issued to the students themselves. The consent and assent forms allowed parents and participants to select their level of involvement, if at all, for the following Yes/No selectable criteria:

(a) complete mathematics assessments;

(b) participate in audio-recorded group discussions;

(c) complete exit slip surveys;

(d) be observed;

(e) participate in an interview;

(f) have an interview audio recorded;

(g) be videoed in class for research purposes only;

(h) be videoed when presenting;

(i) participate in showing the finished module to another student; and

(j) having an excerpt or still of a video used during live presentations but not published.

The participants were informed that their identity and that of the school and town would be de-identified with the use of pseudonyms and any other measure to protect the identity of the participants. Please see Appendix A for a copy of the explanatory statement, the consent form (for parents) and the assent form (for students).

The participants were informed that they could withdraw from the study at any time without giving an explanation. Two aforementioned students officially withdrew from the study in the first session when (as reported to me by Serena) they learnt that students would be creating multiple-choice questions for peers and the e-learning module would be presented to students in the other Year 8 mathematics class in the school for feedback.

To help address the potential perceived power difference between students and teacher, the students were advised they could submit their written responses anonymously if they chose. It was deemed important that the participants felt safe to respond honestly without fear of recrimination or censure (Miles et al., 2014), or peer comparison (see Tsivitanidou, Zacharia, & Hovardas, 2011).

## 5.8 Methods

The methods for collecting data were chosen to give multiple perspectives on engagement at the activity level, that is, from the students themselves, from the teacher's perspective, from the researcher's (my) perspective, from students' later reflections (weeks after the activities), from the artefacts the students produced (or did not produce) and also from video evidence. Data were collected from multiple sources to potentially triangulate the information, provide more than one perspective and attempt to reduce researcher bias (Creswell, 2013).

### Planning of lessons

The lessons were planned to address the need for students to learn fractions concepts to progress in the study of mathematics and help form the basis for sound numerical fluency outside of school. Students were asked to both demonstrate and explain to others these important ideas by co-creating an e-learning module on fractions concepts. The problem of needing to understand multiple fractions concepts and of strategically overcoming common fractions misunderstandings was planned to be delivered as presentations of information interspersed with brief collaborative, discussion-based or hands-on activities. It was further explained that the intended audience for the e-learning module on fractions was to be other Year 8 students at the school. It was explained that these other students would be asked to give peer feedback on the module (see Black & Wiliam, 2009; Smith et al., 2002; Tsivitanidou et al., 2011).

I had planned that the students would first explore common misunderstandings involved in the part-whole concept of fractions because this is likely to be that in which students are most familiar (Charalambous & Pitta-Pantazi, 2007; Clarke et al., 2011). Charalambous and Pitta-Pantazi (2007) found that the fractions concepts of part-whole, ratio and measure and the sub-construct of equivalence are conceptually related. I had planned that the e-learning module would concentrate on these links and that this would help the students forge conceptual connections between concepts. Please refer to Table 5.1 for the planned lesson sequence and the fractions concepts covered. However, this plan was not followed; the complex and intriguing reasons for this are explained in Chapter 6: Classroom Tensions — When Researcher Assumptions Meet Classroom Realities.

Table 5.1

*Proposed Lesson Sequence Linked to Fraction Concepts*

| | Proposed lesson or part lesson | Fractions concepts covered |
|---|---|---|
| 0 | Explain study, data to be gathered and consent and assent forms | NA |
| 1 | Pre-test — fractions<br>Explain e-learning module project | All fraction concepts based on (Charalambous & Pitta-Pantazi, 2007) |
| 2 | Learn about fractions concepts with presentations and short activities | All fraction concepts and equivalence |
| | Appraise interactive DLOs in Scootle[a] | Mainly part-whole, ratio and measure concepts |
| 3 | Learn about fractions misconceptions and harder part-whole concepts | Start with part-whole fractions misconceptions<br>Presentations with short activities |
| 4 | Make MC tests based on pre-test results & misconceptions | All fraction concepts as per pre-test results but concentrate on part-whole, ratio and measure concepts |
| 5 | Students explore module hosting software | NA |
| 6 | Look at ‘Maths is Fun’ website | See how others explain part-whole, ratio and measure fractions concepts |
| 7 | Make stop-motion animations; videos A | Start with unit fractions and extend part-whole concepts to improper (top heavy) fractions |
| 8 | Make stop-motion animations; videos B | Make connections between age-appropriate ratio concepts (gradients and speed) and fractions |
| 9 | Make races, ranking tasks & word-searches in hosting software | Concentrate on part-whole, ratio and measure concepts and equivalence |
| 10 | Students help compile module in hosting software | NA |
| 11 | Show completed module to known peers for feedback | All fractions concepts |

*Note*. MC = multiple choice; DLO = digital learning object; NA = not applicable
[a] Scootle is a repository of digital learnings objects linked to the Australian Curriculum.

**Data collection**

Seven sources of information were collected for this exploratory case study, three of which, the exit slips, questionnaire responses and focus group discussion directly canvassed the students' perceptions of engagement or otherwise. The data collected are listed here briefly and described further below:

1. Student exit slips
    - Administered after a lesson
    - For a copy of each of the two exit slips used, please refer to Appendix B for the original exit slip used and the modified version with the extra prompt 'because…' after both the main open-ended questions
2. Student questionnaire on responses to activities
    - Please refer to Appendix C for a copy of the questionnaire
3. Researcher journal entries
4. Semi-structured interviews with the teacher — audio-recorded and transcribed
    - Conducted before, during and after the lesson sequence
5. Classroom videos
6. Focus group discussion with eight of the students
    - Conducted after the lesson sequence
    - Please refer to Appendix D for a copy of the focus group questions and to Appendix E for a transcript of the focus group discussion
7. Student produced artefacts
    - Produced during the lesson sequence
    - Please refer to Appendix F for a selection of student artefacts produced throughout the project and for links to the stop-motion animations the participants co-produced

***Exit slips.*** In the research literature, the effectiveness of exit slips is well recognised as quick, informal written formative assessments of students' understanding or reflective evaluation surveys administered by teachers at the end of a lesson (e.g., see Leigh, 2012). In this study, I used exit slips to gather engagement data from the students at the end of lessons. The exit slips had open-ended prompts and five-point Likert scales on students' perceived engagement and learning level during the lesson. Students could elect to divulge their names or to remain anonymous. The open-ended prompts included the following:

- 'I was most engaged when I was…'
- 'I was least engaged when…'
- 'It helped me learn when…'

Two Likert scale ratings from 1 to 5 were presented within the exit slips

- 'I felt engaged in today's session'
    - '1 – Not at all' to '5 – All or nearly all of the time'
- 'I learnt well in today's session'
    - '1 – Strongly disagree' to '5 – Strongly agree'

For one of the lessons, a slightly modified version of the exit slip was administered which included the extra prompt 'because' after the first two main prompts. That is, 'I was most engaged when I was… because…' and 'I was least engaged when… because…'. These additions were intended to elicit additional worthwhile information from the students.

The Likert scale self-ratings of engagement and learning involvement were considered useful for the following reasons:

- ✓ The results gave an indicator of engagement and learning;
- ✓ Patterns and links could be seen between ratings and written responses within the one instrument;
- ✓ Where the students divulged their names on the exit slips, links could be made between observed behaviours from video evidence;

- ✓ The ratings allowed the exit slip data to be sorted and presented in ranked order, in terms of combined engagement and learning level, in a spreadsheet program, Excel, and further thematic patterns noted both within lessons and with pooled data across the five lessons where the exit slips were administered;
- ✓ The sorted and ranked order of the exit slip responses was useful in identifying, labelling and referring to individual responses within the largely anonymous data.

For the last item, please see below for more information in the section headed ‘Labelling anonymous responses’.

***Questionnaire.*** The questionnaire was employed nearer the end of the project at Lesson 10 to help understand the students’ responses to several key topics covered in the lessons (e.g., fractions concepts; common fractions misconceptions; and benchmarking and visualising with fractions) and activities from Lessons 2 to 7 (it was developed during the course of the study and additional ethics approval was sought and gained before administration). The exit slip prompts generated useful data, but many responses were very brief, most often consisting of three or less words. The questionnaire items were in ‘prompt-because’ pairs. For example, ‘I found learning about difficulties people have with learning fractions…’ ‘because…’.

***Researcher journal entries.*** The researcher journal entries were mostly in the format of verbal recounts of the happenings, observations, reflections and feelings of the lesson dictated into transcription-enabled software, Google docs, and then immediately checked and altered for sense. These were recorded the same day or the day after the lesson. Other journal entries were jottings in paper notebooks recorded throughout the study and as recollections during the writing-up period.

***Semi-structured, audio-recorded and transcribed interviews with the teacher.*** Ten semi-structured interviews were audio-recorded with the classroom teacher, Serena, either immediately after the lesson or before the lesson the following week, Serena’s time permitting. The interviews were conducted in Serena’s office, which she shared with five other staff members. The duration of the interviews ranged from 5 minutes to just over an hour for the last interview. At first, a copy of the questions to be asked were shown before the interview. As the study unfolded, the interviews became more conversational with both of us asking and answering questions (although the ‘set’ questions were still asked). A small, battery-operated digital recording device was used (Sony ICD-PX470//CE Voice Recorder) with the researcher’s iPhone as a backup. These interviews were transcribed using a commercial transcription service (A Way with Words) and checked against the original sound recording.

***Classroom videos.*** Nine lessons were videoed. A Zoom Q8 Handy Video Recorder (which recorded sound too) was mounted on a tripod at the front of the room and directed towards the class. As noted above, the two non-participants of the study within the class were seated behind the camera and provided alternative mathematics work by their class teacher.

Not all lessons were successfully videoed in entirety. Lesson 2 was not videoed because another class occupied the school’s computer room prior to the lesson, and the apparatus could not be set up in time. In Lesson 5, I unfortunately forgot to press the record button. In Lesson 8, the class had school-mandated online assessments to complete, so both the recording and the lesson were delayed and truncated. In Lesson 11, the power went off about half-way through the lesson.

***Focus group discussion.*** The focus group discussion (and the end-of-project break-up party which followed) was conducted within the regular classroom (not the computer room) and 17 consenting students were invited to participate in the discussion (all class members were invited to the party afterwards). The students seemed reluctant to participate unless in the same room as the rest of the class, so a table was set up within the classroom. The focus group discussion was audio-recorded using a Sony ICD-PX470//CE Voice Recorder at one end of the table and an iPhone at the other. There were eight participants, and the discussion was for just under half an hour (29:20).

***Student-produced artefacts.*** In this study, student-produced digital media and other products for the e-learning module were collected as evidence of engagement in that the students completed or attempted to work towards the learning activity aim. Over the course of the project, the students created a game, four stop-motion animations and 37 videos. They worked on creating digital images using the raster graphics program, Paint, and solving problems in groups.

**Labelling anonymous responses**

Much of the written data collected from the students, that is, all the questionnaire responses and most of the exit slip responses, were anonymous. As noted earlier, the decision to respond anonymously or otherwise was left to the students. If a student included his or her name, then a pseudonym was used, thus protecting real identities.

To differentiate between each of these anonymous responses, a code was used:

(a) the type of data collection
   i. ‘Qs’ for the questionnaire data, and
   ii. ‘Ex’ for the exit slip data;

(b) a unique identifier not linkable to real identities.

For the questionnaire data, all of the responses for each of the 15 individual students who completed the questionnaire (Lesson 10) were simply labelled with the prefix designating questionnaire data, Qs, a letter identifier, A to O, and followed by the abbreviation ‘Anon’ to remind the reader that the responses were anonymous. For example, ‘Qs-K-Anon’ refers to a response from the questionnaire from the anonymous individual student denoted as ‘K’.

The exit slips were administered for five lessons: Lesson 4, 12 May 2017; Lesson 5, 19 May 2017; Lesson 7, 2 June 2017; Lesson 9, 23 June 2017; and Lesson 11, 21 July 2017 – a total of 69 exit slips across the study. Exit slips were administered just before the lesson ended, time permitting. Most exit slip responses were anonymous and necessitated labelling with a unique identifier. Denoting each of the 69 exit slips with letters was considered unwieldy (unlike the questionnaire, which was administered once to 15 students; a letter identifier was deemed sufficient to discriminate between responses). Unique exit slip descriptors were therefore generated, which linked the slip to the lesson, the number of participating students and the student's self-rated engagement and learning level:

(a) Data type code

- Ex = Exit slip

(b) Lesson number

- E.g., Ex-L4 means an exit slip from Lesson 4

(c) Ranked identifier number

- Using a Likert scale prompt, students were asked to rate both their engagement and learning level of that lesson in the exit slip from 1 (low) to 5 (high).
- The exit slips were sorted in ranked order in the spreadsheet program Excel by students' self-reported (SR) engagement level and then by students' SR learning level for that lesson such that the higher the number the higher the SR engagement and learning. The number of students present for that lesson was written after a forward slash.

(d) Student's pseudonym (e.g., Zach), or if unavailable, the abbreviation 'Anon' was used.

For example, 'Ex-L4-10/12-Zach' refers to an exit slip response in Lesson 4 from the third highest SR ranking for combined engagement and learning out of $n$ =12 for that lesson from Zach (pseudonym). The descriptor 'Ex-L4-2/12-Anon' refers to an exit slip response also from Lesson 4, but in this case, from the second lowest SR ranking (for combined engagement and learning) out of the same 12 students for that lesson. In this case, the identity of the student is unknown.

**Analyses and coding**

The students' written data initially were analysed using the qualitative data coding software, NVivo. The responses from the exit slips and questionnaire were entered into Excel (question prompts heading each column; one respondent per row; and one response per cell), uploaded to NVivo, then sorted into themes. The students' exit slip responses and the questionnaire responses were inductively analysed (Creswell, 2013; Yin, 2014). The frequency of responses for any theme was noted as an indication of the relative importance of it for the participants (Creswell, 2013). To complement this, the relative frequency (importance) of thematic words was investigated using NVivo. Many of the themes which emerged from the data were found to resonate with the expectations of the theoretical framework (discussed in Chapter 4: Defining Engagement and the Theoretical Framework). However, some additional themes arose from the data analysis which were unexpected. For example, ‘I hate computers’ was an unexpected theme to emerge.

***Broad themes and emotion markers.*** The themes were then gathered, or reassembled (Yin, 2014), into broader levels such that two, perhaps expected, broad themes emerged — engagement and disaffection — with some more minor themes, including distraction and compliant or mild engagement. The emotions of enjoyment and interest were helpful as markers flagging engagement and the emotions of boredom, frustration and lack of interest were used as markers of disaffection. Pointlessness and irrelevance were categorised as disengagement.

***Sub-themes.*** Most themes and sub-themes were expected (please refer to Table 5.2 for a list of the themes and sub-themes coded) — in line with the working definitions of learning engagement and disaffection, and the theoretical framework for the study (based on self-determination theory, expectancy value theory and the control value theory of achievement emotions). However, the sub-themes of working, not fun, pointlessness, too much passivity and socialising-not-learning emerged inductively and so were not initially expected, but in hindsight made sense with the theories, as discussed in the findings chapters. Distraction was not coded as either disaffection or engagement as it was not always clear if being distracted was a backhanded acknowledgement of the value of the learning (thinking perhaps, ‘I want to learn this, but the talking is distracting’) or conversely a welcome avenue to escape working on the learning activity. Some responses were coded as compliant or mild engagement because they were neither sufficiently strong in demonstrating involvement in a learning goal nor demonstrated disaffection. For example, in reply to the questionnaire prompt-because pair, ‘I found learning about the visualising of and benchmarking with fractions… because…’ the response ‘it was a bit interesting… as it was visual' (Qs-L-Anon) was categorised as mild engagement under compliant engagement. Some suggestions for improvement were not coded as disaffection because, although about perceived negative elements, wanting to improve learning conditions could be construed as indicating engagement. However, other suggestions like 'Having a better instructor' (Qs-I-Anon) were categorised as disaffection.

As various themes emerged from initial analysis of the students' written responses, corroboration or challenge of these themes was sought in other data: transcript of the focus group discussion; teacher interview transcripts; researcher journaling; student-produced artefacts and video evidence. The other written responses and transcribed data types were openly explored for themes too, but not all of these related to or foreseeably impacted on students' engagement in the learning activities.

Analysis of the video documentation of the lessons was more deductive than inductive in looking for student behaviours (physical actions) interpretable as engagement (working towards a learning activity goal). This was particularly where the students' gaze (e.g., see Gobert, Baker, & Wixon, 2015) appeared to be directed towards learning objects or a person speaking about the task in hand, and, although an interpretation, appeared to be gazing with interest or task-oriented cognition.  For example, playing with and looking at fractions pieces while chatting socially was not documented as engagement but moving fractions pieces to show equivalent fractions in alignment with the lesson's aims was documented as learning engagement.

I watched each classroom video several times and noted, time stamped and took a still capture, when I interpreted the students' physical actions as evidence of being engaged, for example, their gaze was directed at the objects involved in the activity, or directed at a person speaking, they were touching learning objects, writing, drawing, measuring, apparently talking about the concepts or procedures, asking or answering questions or leaning towards others in a group apparently working on or discussing a task. Evidence of disaffection was also sought, for example, prolonged time spent not looking at the objects in the activity, yawning, looking away from the person speaking or apparently doing something else not related to the learning activity aims. Stills of pertinent moments used in the discussion of the study were presented to my supervisors to help cross-check that the students did reasonably evidence engaged or disaffected actions.

**Presenting the data**

Once the themes were coded, I wanted to know if certain patterns of themes or self-rated engagement or disaffection seemed to be linked with particular conditions or activities. Whereas NVivo, a qualitative data analysis program, was useful for identifying themes, word frequency data and displaying word frequency visually for presentations, an Excel spreadsheet, when colour-coded by theme, was deemed helpful for seeing patterns of themes. I found that NVivo fragmented the prompt-because pairs whereas analysis with a spreadsheet was more context-specific for this small data set, and as such was chosen for analysing most of the data once the themes were identified in NVivo. Also, in Excel, I could insert a ‘theme’ column next to each exit slip response column and label each response’s theme. This meant I could sort the data quickly into themes and see frequencies of themes within the data and colour-code responses by theme to see patterns of responses.

**Colour-coding.** Engagement was colour-coded in shades of green (symbolising, for me, growth) and disaffection and disengagement were colour-coded in opposite shades of deep pink and red respectively. Passivity was coloured grey, distraction yellow, computer themes were designated blue and suggestions were coloured aqua. The same colour-coding of themes was used to code both the exit-slip and questionnaire responses.

Table 5.2

*Themes Coded and Colour Coded*

| Major theme | Sub theme | Included |
|---|---|---|
| Engagement (in learning) | | Working |
| | | Interested |
| | | Concentrating |
| | Enjoying | Fun |
| | | Good easy |
| | Creating | Creating animations |
| | | Creating videos |
| | Others help learning | Presenting to others |
| Compliant engagement | Mild engagement | Procedural focus |
| | | Neutral |
| Disengagement | Pointless | Don't care |
| | Irrelevant | |
| Disaffection | Boring | |
| | Frustrating | Annoying |
| | Too much passivity | Listening |
| | | Watching |
| | | Sitting too long |
| | Not fun | |
| | Already known | Too easy |
| | | Repetitive |
| | Childish | |
| | Too hard or confusing | |
| | Others hinder learning | Socialising (not learning) |
| Distraction | Distracted | |
| Computers (blue) | Computers good | |
| | Computers bad | I hate computers |
| | | Logging in problems |
| Suggestions | | Method needs improving |
| | | Equipment needs improving |
| | | More choices needed |

Please refer to the following for thematic colour coding:

(a) Table 5.2 *Themes Coded and Colour Coded* for the colour coding themes used;

(b) Table 7.8 *Categorised, Sorted Exit Slip Responses from Lesson 4 — Presentation and Short Activities on Fractions Area Concepts* for an example of a display of exit slip responses for a lesson within Excel colour-coded by theme;

(c) Appendix G for the display of all 69 pooled exit slip responses colour-coded by theme and sorted by students' self-rated engagement level, then learning level, presented first in date order then again in total cohort ranked order; and

(d) Appendix H for the students' responses to the questionnaire also colour-coded by theme (presented twice to account for the eight responses with two themes).

Eight responses from the questionnaire needed to be coded for more than one theme (easily handled within NVivo) but only one theme per cell could be colour-coded in Excel on the same sheet. For example, 'the work is too easy and I don't like computers' (Qs-D-Anon) was coded under the theme 'already known' (which includes the themes 'too easy' and 'repetitive') on one sheet and was coded as 'computers bad' on the other sheet. Three of the double-coded responses included suggestions for improvement.

## 5.9 Concluding this Chapter

Involved previously in biomedical science research and therefore quantitative studies, I found that conducting this qualitative study required a personal, and seismic, paradigm shift. I eventually came to understand that reality is constructed for each person within his or her social and cultural environment and that it was important in this study to represent my own and other participants' perspectives as truthfully and authentically as I could. I also concluded that I could not, in this paradigm, explore causation as such, but rather evidence for what works, or seems to work, or otherwise, in engaging students at the learning activity level. The value of qualitative research then, for me, is three-fold: (a) the candid acknowledgement and documentation of 'the other' and 'self' in a real-life setting; (b) exploration of the theoretical interplay of the findings; and, pragmatically, (c) an investigation which readies the way for further research, if warranted.

The questions of validity were addressed in this study by making sure the data were trackable, using direct quotations from the participants themselves and triangulating multiple methods and data types. The data were discussed within a theoretical framework referencing three well-researched theories: self-determination theory, expectancy value theory and the control value theory of achievement emotions.

This exploratory case study was set in a Year 8 mathematics class with 17 student participants and their expert mathematics teacher, Serena, in a small government (public) school in regional Victoria, Australia. The students were invited to participate in activities to co-create an e-learning module on fractions. The e-learning module was only partially completed in the 13 lessons over two school terms. During this time, care was taken to ensure that the participants felt safe: their identities were protected by the use of pseudonyms and the students were offered the choice to submit written responses anonymously.

Most of the data collection methods were those well known in qualitative research: open-ended questionnaires; semi-structured interviews with the teacher; researcher journaling; videoing of the lessons; student-produced artefacts; and audio-recorded focus group discussion. Another data collection method, exit slips, although well used by teachers for formative assessment, was developed for use in this study. Exit slips were used to gather students' self-rated appraisals using 5-point Likert scales of their engagement and learning levels and times when most and least engaged. The questionnaire and exit slip data were inductively analysed in the qualitative data coding software, NVivo, and assessed within the spreadsheet program, Excel, for patterns of themes. Both programs were used to display findings, but Excel was used to explore patterns in themes with the use of colour-coding. These findings and patterns are the subject of the next three chapters.

# Chapter 6: Tensions — When Researcher Assumptions Meet Classroom Realities

This is the first of three findings and discussion chapters for this study in which I explored learning activity engagement of a class of Year 8 students invited to work on creating or appraising digital elements for an e-learning module in fractions. Although keen to study engagement, as outlined in the introduction of this thesis, I quickly found the project was not going to proceed as planned. In this chapter, I discuss and explain what seemed to derail the project and set it on to a different, perhaps grittier and more intriguing, pathway.

## 6.1 Signposting this Chapter

In this chapter, I explore the students' responses which were, for me, counter to expectations.

In section 6.2 Definitions, I re-outline the definitions used in this study.

In section 6.3 Project Context — E-Learning Module Not Completed, I discuss what appear to be the main reasons why the e-learning module stalled and was not finished. I explain how the focus shifted to the findings of interest, engagement at the learning activity level.

In the next four sections, I describe three conditions and an activity to which the students responded in ways I did not anticipate:

(a) 6.4 Peer-to-Peer Assessments — Unforeseen Issues;

(b) 6.5 Target Audience for the E-Learning Module;

(c) 6.6 Appraising Digital Objects — More Surprising Issues; and

(d) 6.7 Unexpected Reactions to and Issues with Computers.

In section 6.8 Discussing of the Findings Through the Theoretical Framework for This Study, as well as referring to empirical research literature throughout discussion of these findings, I draw upon self-determination theory, SDT (Deci & Ryan, 2000), expectancy value theory, EVT (Wigfield & Eccles, 2000) and control value theory of achievement emotions, CVTAE (Pekrun,

2006) which in concert have provided me with fruitful ways to reason about student engagement and which formed the theoretical framework for this study.

## 6.2 Definitions

The working definitions of engagement and disaffection were discussed and explained in Chapter 4: Defining Engagement and the Theoretical Framework. Please refer to that discussion for a derivation and the references used to propose these working definitions and descriptions. The following definitions and descriptions are listed here for ease of referral.

**A working definition of learning activity engagement**

Learning activity engagement is behaviour and mental processing directed towards achieving learning goals and is associated with enjoyment or interest.

**A working definition of learning activity disaffection**

Disaffection is characterised by the lack of action or mental processing directed towards achieving learning goals and is associated with boredom, frustration or a lack of interest.

**A working definition of learning activity disengagement**

Learning activity disengagement is switching off from a learning activity with no action or mental processing directed towards achieving the learning goal and is feasibly associated with negative achievement emotions: boredom, anxiety, anger, shame and disappointment.

**Compliant engagement description**

Compliant engagement (see Crick, 2012) is differentiated somewhat from disaffection and describes low-energy behaviour, with low emotional outputs, which might appear to be directed towards a learning goal, but it is actually directed towards complying with social norms, not learning.

**Boredom**

Boredom is generally ‘a state of weariness or ennui resulting from a lack of engagement with stimuli in the environment’ (American Psychological Association, 2018), but the reactant subtype is a high energy state seeking escape (Goetz et al., 2014).

These definitions and descriptions are used throughout this and the following two results and discussion chapters and the concluding chapter. For a more detailed discussion, please refer to Chapter 4: Defining Engagement and the Theoretical Framework.

## 6.3 Project Context — E-learning Module Not Completed

The initial overall project goal for this study, for students to co-create an e-learning module for peers, was not completed. However, over the nine full teaching lessons (plus a half lesson after administering the questionnaire and three further sessions with pre- and post-testing and the focus group discussion) the module was created in part. Indeed, the students created a game, four stop-motion animations and 37 videos. Considering the e-learning module on fractions was not completed, I shifted my research focus to the conditions, activities and activity characteristics which the students seemed to find engaging, or otherwise.

There appear to be multiple contributing factors for the project’s non-completion which will unfold in the ensuing discussions in this and the next chapter. In this chapter, I describe the situational and pre-existing factors which appear to have affected the students’ engagement and my assumptions as the researcher that were apparently not borne out in the classroom. In the next chapter, I describe the activities, activity characteristics and conditions which appeared to be disaffecting for the students.

**Situational or pre-existing factors**

The following situational or pre-existing factors may have impacted the students’ engagement throughout the duration of the study.

***Social comparisons with the other Year 8 class.*** The Year 8 students at Rivertown HS were streamed by literacy achievement. I was with the advanced group; there was one other Year 8 class at the school. Over the months visiting the school, I often walked through the schoolyard during recess and saw the students regularly playing with their friends from the other Year 8 class. It appears plausible that there were some heightened social tensions for the students to manage regarding comparisons that I was not aware of at the beginning of the project.

***Last period on Friday.*** The lesson timeslot for which I was with the class was last period on a Friday. The students sometimes appeared tired. In an exit slip, Zach wrote that he was least engaged when 'not working' because 'it is Friday' (Ex-L8-11/17-Zach)[3]. It seems plausible that the timetabled mathematics lesson for last period on a Friday may have negatively impacted some students' engagement levels. On the other hand, in US secondary schools ($n$ = 125,223) Allensworth and Luppescu (2018) reviewed that although time of day can have an impact, particularly for at-risk students (*first* period is the most difficult for these students), it is not a powerful determinant on achievement compared to the students' effort and skills.

***Apparent entry level technological skills.*** The Rivertown HS Year 8 students seemed to be at the entry level of technological skills and use. According to Neyland (2011, p. 152), use level of technology ranges from 'non-use, through stages such as entry, and adaptation, arriving at transformation — when a focus on technology shifts to a focus on the learner'. When conducting the study, some students needed to be shown how to use readily available programs including Microsoft Paint and PowerPoint, and they did not appear to be practised at gaining access to password-protected websites or a learning management system (LMS). Concentrating on the latter which needed logging in practice, and as discussed below, this apparent lack of skill seemed to affect the trajectory of the project and the engagement of the students.

[3] Please see Section 5.8 Methods – Labelling Anonymous Responses for information on how student responses, both anonymous and linked to pseudonyms, were labelled from the exit slip and questionnaire data.

***Anxiety about testing.*** Some students seemed to exhibit heightened anxiety about testing. For example, the classroom teacher, Serena, did not want the pre-tests on fractions concepts returned to the students because some tended to react poorly to low marks. Serena explained in an unrecorded conversation that one student had just received a low mark on a test on the previous topic in mathematics (of all topics, on fraction and decimals; please see directly below) and refused to take the marked test home to parents.

***Potential topic saturation.*** The previous topic that the students studied in their mathematics class was fractions and decimals. Serena seemed to think it might help consolidate the learning, but it seems plausible that spending an extra 10 plus weeks on the topic may not have been engaging for some students.

## 6.4 Peer-to-peer Assessments — Unforeseen Issues

After an initial presentation I gave to the Year 8 mathematics class, two students went to their teacher, Serena, and stated they no longer wanted to be part of the project and formally withdrew from the study. Other students apparently also expressed concerns. So, what happened? What made the students so uncomfortable?

During that presentation I reminded the students what an e-learning module was (a mini-course on a specific subject available online) and explained that our target audience would be the other Year 8 class of students at the school. I proposed to the participating class of Year 8 students that we would be using their collective knowledge, as a class of in-house experts, on what Year 8s tend to like and need to inform the creation of the module. I outlined the trajectory of the project, including that the students would be making multiple-choice (MC) questions for quizzes and for pre- and post-tests for the module, and when completed, the e-learning module would be assessed by peers at the same school to give constructive feedback. Please refer to Table 6.1 showing the proposed trajectory of the lesson sequence and Table 6.2 for the actual lesson sequence with researcher notes and illustrative examples from the students indicating their responses to the activities.

Serena told me that, after I left, many students told her that they did not want to create multiple-choice tests for peers or have the proposed finished module assessed by peers at the same school. One student thought she would have to create and deliver an assessment by herself. Apparently, Serena was mostly able to assuage their fears, but two students chose not to proceed. (These latter students stayed in the same classroom, did not partake in the project activities, were given related mathematics work by Serena and were seated so the classroom video cameras did not capture their images). In reference to peer-to-peer assessments, I wrote in my journal, ‘I had no idea that would be a big problem for them’ (Researcher reflection; 21st April 2017).

Creating assessments with the students was planned to be a keystone feature of the creation of the e-learning module on fractions. I envisaged that students would gain conceptual understanding by creating and discussing good multiple-choice questions and would enjoy testing each other. With senior secondary science students, Hardy et al. (2014) and Yu and Liu (2005) found that formulating, sharing and discussing multiple-choice questions afforded new insights for their students, but I could not trial or implement that strategy with these Year 8 students without risking more widespread disaffection and potentially more students leaving the study.

Despite the set-back, I hoped that with different strategies and by presenting the idea more sensitively, I could win the students’ trust, and then trial the creation of multiple-choice questions successfully with them. However, it became apparent as the project proceeded that trialling peer-to-peer assessments further, and indeed pressing on to finish the e-learning module as planned, was neither feasible nor fair to the students or their teacher. Nonetheless, I considered it fruitful to explore why the students were so uncomfortable.

Table 6.1

*Initial Planned Activity, Actual Inclusion and Explanations or Extra Information*

| | Initial planned activity | Included ✓, ~ or X | Explanation or extra information |
|---|---|---|---|
| 0 | Explain study | ✓ | Issued & explained consent and assent forms |
| 1 | Pre-test — fractions | ✓ | Classroom teacher did not want pre-tests returned to test-anxious students |
| | Explain e-learning module project | ✓ | When hearing about peer-to-peer assessments, two students left the study |
| 2 | Learn about fractions concepts | ✓ | Mainly disaffection |
| | Appraise interactive DLOs in Scootle | ✓ | Logging in issues. Some students appeared to react to juvenile content |
| 3 | Learn about fractions misconceptions | ✓ | Some positive engagement but mainly disaffection |
| 4 | Make MC tests based on pre-test results & misconceptions | X | See Items 1 and 2<br>Group problem solving instead |
| 5 | Explore module hosting software | ✓ | Logging in issues |
| 6 | Look at ‘Maths is Fun’ website | X | Another passive activity. Perhaps could have been done earlier. Needed some ‘wins’ |
| 7 | Make simple stop-motion animations; videos | ✓ | Seemed to be mostly engaging for the students |
| 8 | Make more complex stop-motion animations; videos | ✓ | Seemed to be mostly engaging for the students |
| 9 | Make races, ranking tasks etc. in hosting software | ~ | Too few students logged in successfully |
| 10 | Students help compile module in hosting software | ~ | Researcher compiled module in PowerPoint instead — easier to edit |
| 11 | Show completed module to known peers for feedback | X | Module not finished<br>Idea abandoned anyway. See Item 1 |

*Note*. ✓ = included; ~ = changed; X = not included; MC = multiple choice; DLO = digital learning object

Table 6.2

*Lesson Sequence and Participants' Reactions to Activities with Source*

| Date 2017 | Lesson activities | Researcher Notes | Illustrative Participant Responses | Source |
|---|---|---|---|---|
| 1<br>21st Apr | Pre-test | Test-anxieties | Teacher did not want pre-test returned to test-anxious students with poor performance | Interview |
| | Explanation of project. Proposed showing module to peers and creating peer assessments | 2 students left study | 'They don't want to be exposed' | Interview |
| 2<br>28th Apr | Learn about fractions concepts<br>(1st attempt appraising DLOs in Scootle; see 5th May for responses) | Most seemingly disaffected<br>Some apparent engagement | 'stupid' because 'it was boring'<br>'boring' because 'I learnt about that in like grade 4'<br>'great' because 'it actually showed me ways to work out different problems' | Questionnaire<br>Questionnaire<br>Questionnaire |
| 3<br>5th May | Learn about fractions misconceptions | Mixed responses | 'boring' because 'it's not my problem'<br>'interesting' because 'I have similar struggles' | Questionnaire<br>Questionnaire |
| | 2nd attempt appraising DLOs in Scootle | Logging in issues<br>Mixed responses<br>Some students appeared to react to juvenile content | 'I couldn't log on'<br>'quite fun' because 'we got to do challenging stuff or things that are the same level as us'<br>'boring' because 'there was nothing there that entreged [sic: intrigued?] me'<br>'annoying' because 'It was aimed at Primary Schoolers' | Questionnaire<br>Questionnaire<br>Questionnaire<br>Questionnaire |
| 4<br>12th May | Learn about other part-whole areas & regions | Mixed responses | I was most engaged when…<br>'working in our books drawing a shape'<br>'we were trying out quizzes and working in groups'.<br>I was least engaged when…<br>'it was boring'<br>'most of the time' | <br>Exit slip<br>Exit slip<br><br>Exit slip<br>Exit slip |

| | | | | |
|---|---|---|---|---|
| 5<br>19th May | Group work problem-solving* | Mostly engaged | I was most engaged when… 'Working with my group' and least engaged when 'you [me, as presenter] were talking' | Exit slip |
| 6<br>26th May | Group work problem-solving* | Mixed responses | 'ok' because 'I was with my friends and I got to talk but that was a distraction...' | Questionnaire |
| 7<br>2nd Jun | Finish group work | Mixed responses | I was most engaged when… 'making movies'; | Exit slip |
| | Student created videos & images | Mostly somewhat engaged | 'On the computer doing the overview [overlay?]' | Exit slip |
| | Watch how-to videos | | I was least engaged when… 'watching videos' | Exit slip |
| 8<br>16th Jun | Showing the shell of what was achieved thus far | Low engagement | 'I was totally flat after the lesson last Friday… the students didn't want to do the tasks anymore' | Researcher journal |
| 9<br>23rd Jun | Rotation of four activities: SMA1; video; PPt SMA2 on computer; compare fractions | Students mostly appeared engaged | 'the funner stuff like stop motion and all that' | Questionnaire |
| | | | I was most engaged when I was… 'making stop motion @ fractions' because 'it was fun' | Exit slip |
| 10<br>30th Jun | Questionnaire administered | | | |
| | Fold over a quarter of *any* triangle | Most students appeared engaged | Eleven out of 15 students tried and completed the task. Two did not participate. Two watched. | Classroom video |
| 11<br>21st Jul | Linking three fractions concepts | Students appeared engaged at plenary | Inv: Any 'Aha' moments?<br>Lissy: How it [fractions] relates to gradients | Focus group discussion |
| 12<br>28th Jul | Post-test | | | |
| | Trial in hosting software | Logging in problems | 'not many students could get on hosting software; the TV didn't work…' | Researcher journal |
| 13<br>26th Oct | Focus group | Engagement noted on making animations | 'It was pretty cool. Like, it was different to what we normally do in other classes' | Focus group discussion |

*Note*. Anonymous responses unless student disclosed name where noted; DLO = digital learning object; Inv = interviewer; STM = stop motion animation; PPt = PowerPoint presentation program * Please refer to Appendix H

**Possible explanations for peer-to-peer assessment problems**

Serena explained the students' responses: 'Some of them don't want to make a test for other classes' (Teacher interview; 2017, May 5; 2:40) because of 'their lack of self-confidence. They don't want to be teachers in front of their peers,' (t = 3:11) and, 'They don't want to be exposed,' (t = 3:39).

Peer-to-peer assessments have been used successfully in higher education (Black & Wiliam, 2009; Smith et al., 2002), and although with apparently fewer reports in the literature, also in senior secondary education (Tsivitanidou, Constantinou, Labudde, Rönnebeck, & Ropohl, 2018) and with early adolescents (Tsivitanidou et al., 2011). Several of my assumptions about this proposed activity were exposed as unworkable in the pre-existing context with this class and the conditions created in this study. I had thought students creating multiple choice questions for an e-learning module would be somewhat like peer-to-peer teaching, so would be socially and academically engaging and effective (Brewer, Reid, & Rhine, 2003; Fantuzzo, King, & Heller, 1992; Leung, 2015; Okilwa & Shelby, 2010; Toumasis, 1990), but in this context it was apparently threatening. I had thought creating multiple-choice assessment items would help the students cognitively engage in the content as this approach seems to be engaging for older students in other disciplines (Rhind & Pettigrew, 2012; Yu & Liu, 2005). I had further thought creating multiple choice questions would help the students feel included in their own education (Dewey, 1986; Scanlon, 2012). However, the idea of creating multiple choice questions with and for known peers was apparently threatening for these students in that two students left the study and several others went to Serena and expressed their fears. Lastly, I had planned to use the pre-test as a formative assessment with the students and for the results to inform them of pertinent MC items to create for the e-learning module. However, the timing of the test (at the beginning, before hands-on activities were offered) and not being able to return the pre-tests to the students possibly helped create the perception that the test was a rather a normatively assessed, summative judgement — the exact opposite of my intentions.

It appears inadequate attention had been given to the social needs of the students in the planning of the project. Peer-to-peer assessments seemed to play on the students' fears and undermine their social need for acceptance (Brown & Larson, 2009) and need to support and be supported by each other (Drolet & Arcand, 2013). It appears that many of these students neither wanted to take on an authoritative role as a teacher within their own class nor with other Year 8s at the same school. It seems they also feared having potential inadequacies and misunderstandings exposed which might threaten their competency or perhaps their academic status, and they wanted to protect valued relationships which the prospect of creating peer-to-peer assessments seem to have potentially threatened.

Juvonen (2000) found that US and Finnish early adolescents would employ face-saving and friendship-saving techniques to preserve social cohesion in the event of poor academic performance. A major ploy noted from those Year 8 students, who were asked to rate their likelihood of response if they performed poorly on an important test, was stating that they were not good at the subject, rather than stating that they had not applied enough effort, in order to gain sympathy from liked teachers and to show peers that they are not a threat to their competency, particularly in normatively assessed environments. It seems that something related may have been happening for this class of Year 8s in that demonstrating superior competency to peers through presenting a learning module may have been thought of as threatening the competency of and therefore the relationships with others, or conversely, presenting something lacking would have threatened the competency of the creators — this class of Year 8 mathematics students. Similarly, it appears that testing for these students was associated more with personal academic worth, and less as feedback for areas of improvement and for that which had been already mastered. So, for these students, creating multiple-choice questions within the classroom and the prospect of presenting the completed module to peers at the same school, which would have included testing, appears to have had a strong social cost with no social benefits.

To have avoided making the students apparently feel uncomfortable and even unsafe, it perhaps would have been better had I not conflated peer-to-peer teaching, which is not conducted anonymously, with peer-to-peer assessments, which are conducted anonymously (Smith et al., 2002; Tsivitanidou et al., 2018; Tsivitanidou et al., 2011). I projected that the corporately produced nature of the e-learning module would have afforded a sense of individual anonymity when the students were asked to create assessments or present the module to peers at the same school. However, these students were unlikely to have had experience of what I was asking them to do and seemed particularly wary of assessments, so they may not have been able to conceptualise assessments as an informal means of checking progress and aiding learning, or in the context as proposed — as an actual learning method itself. Furthermore, in a class with reportedly some students with test anxieties, proposing that students create assessments for peers on the same day as completing a pre-test on fractions was probably not good timing. It appears a more sensitive approach which ensured anonymity for the students might have been better received.

These findings will be further considered in the terms of the theoretical framework at the end of this chapter. Before that, several other findings need to be discussed: (a) the problem of sourcing a new target audience for the e-learning module; (b) exposing another assumption regarding asking students to assess learning digital learning objects; and (c) unexpected student reactions to using computers.

### 6.5 Target Audience for the E-Learning Module

In the first two weeks of the project, Serena intimated that the level of engagement was like that of regular classes and noted the engagement level of the class:

> About 40 percent are really doing well. The other 60 percent we had to go to them and tell them about the importance of it; we had to motivate them and brainstorm with them. But they were all doing it. (Teacher interview; 2017, May 5; 6:01)

A month after the students were briefed about the finished e-learning module being presented to known peers at the same school for assessment and feedback, and that plan being abandoned after strong opposition was expressed, the issue of the target audience still had not been resolved. It appeared to me that the engagement level was slipping somewhat. I journaled that the students were ‘engaged somewhat but they're not fully switched on — like making a cup of tea with lukewarm water — we have all the ingredients but something’s not quite right’ (Researcher journal; 2017, May 21).

After speaking to another mathematics educator, I thought we would trial his suggestion to change the target audience for the e-learning module from Year 8 students to Year 5 or 6 students. Serena had reservations but thought it worth trying. This implemented change did not seem to improve the engagement of the class. Rather, it seemed to make the project less relevant for some students. In the questionnaire, administered near the end of the project, the students were asked about how they would have viewed assessing DLOs in Scootle for use in creating an e-learning module for Year 5 or 6 students, and a typical response was ‘It would be easy for me as a year 8, year 5s and 6s should assess it’ (Qs-O-Anon). Please see Table 6.3 for more responses. It was rather awkwardly suggested that the target audience for the e-learning module would be Year 8 students for the harder concepts and Year 5 students for the easier concepts.

A resolution on what target audience these Year 8s might have preferred seems to have come from the focus group discussion after the teaching lessons had ended. When asked if this project were to be run with another group similar to themselves, how might they feel if their finished work were to be shown to other Year 8s, no one responded verbally, but Zach, in particular, shook his head strongly. Eventually, mainly through nodding and shaking responses, it seemed that these Year 8s thought another Year 8 class might like to make an e-learning module for others, but it should be for unknown other Year 8s, not those at the same school, and that the creators would remain anonymous. This appears to be in concert with literature findings that peer assessments aid both the assessor and assessee to improve conceptual understanding and make adjustments to their models or presentations if the reciprocal assessors are anonymous (Tsivitanidou et al., 2018; Tsivitanidou et al., 2011).

When asked, ‘What about when it was posed that you make the project for Year 5s. Was that the right move? What would you like to say about that?’ Toby answered, ‘Maybe Year 5s should be doing it for Year 5s,’ and Lissy said, ‘We had to, like, think of what Year 5s do, and I couldn’t really remember’.

## 6.6 Appraising Digital Learning Objects — More Surprising Issues

There were two findings of note when the students were asked to appraise digital learning objects (DLOs) in Scootle: (a) logging in to a password-protected website proved to be a logistical problem; and (b) some students appeared affronted by seeing juvenile content regardless of the type of content. I discuss logging in problems below under section 6.7 Unexpected Reactions to and Issues with Computers; sub-section ‘Logging in log jams’. In this section, I discuss the students’ responses to juvenile content.

### Juvenile content — ‘It was Aimed at Primary Schoolers’

The first online activity for the project was for the students to assess DLOs in Scootle as to their suitability to include in the module. I envisioned that the students would enjoy taking on the teacher role and assessing learning objects for peers. I thought being invited into a teacher role would make them feel grown up. I also thought it would be a safe way for those without a strong conceptual understanding of fractions to engage in material below their level without being embarrassed in thinking that I believed this is what they needed. I thought the drive to be competent under self-determination theory (SDT) (Deci & Ryan, 2000) would help the students engage. Furthermore, I thought the students would enjoy rejecting DLOs that were too ‘kiddie’. However, added to the frustrations in logging on to the actual Scootle site (see below) and some DLOs not opening, most students did not warm to the idea.

After I demonstrated how to use the filter functions on the site, the students were asked to browse the site for suitable DLOs in Scootle to use in our project. The students were issued with sheets to assess each DLO for its suitability for inclusion into the project on four criteria: (a) Does the learning object open? (yes/no); (b) Is it age appropriate? (yes/no); (c) Is it easy to use? (yes/no); and, (d) It is worthwhile to include in our module? (rating out of 5). There was space for the students to write any notes. Some DLO suggestions for the students were already on the sheets. Please refer to Appendix I for a copy of the sheet used for students to record their appraisals. The students were not asked to rate if they learnt anything from the DLO in case they might be embarrassed in disclosing or admitting they did not know the content beforehand.

The second session was videoed. When students were sent off to appraise DLOs in Scootle, they went to the computers readily enough and after getting through considerable logging in problems (please see section 6.7 Unexpected Reactions to and Issues with Computers; sub-section ‘Logging in log jams’), most of the class appeared to try the activity. However, one group had navigated away from Scootle and had to be asked on at least one occasion (the presenter’s voice [mine] can be heard on the video but the screens were not clearly visible) to stay on task and not engage in a game, not aligned with the learning task (Video of Lesson 2; 2017, May 5; 7:34). It appeared that many students were not having discussions about the task; I assumed they did not know yet what to do. I explained the activity again and showed them with an example how to filter out unwanted DLOs and how to fill in the appraisal form. However, only one pair handed in an appraisal form. It was not known until several weeks later when the students were surveyed with the questionnaire what were the apparent sources of disaffection.

Table 6.3

*Selected Students' Questionnaire Responses on Appraising Digital Learning Objects in Scootle*

| Apparent engagement theme | Student response* | Looking at DLOs in Scootle for Year 8s was… | Looking at DLOs for Year 5 or 6s to use would be... | DLOs I would find effective for learning fractions would |
|---|---|---|---|---|
| Disengaged | Qs-A-Anon | 'useless' because 'it seemed pointless' | 'also useless' because 'it seemed pointless' | 'not exist' |
| Disaffected | Qs-F-Anon | 'boring' because 'there was nothing there that entreged [sic: intrigued?] me' | good for the younger generation | 'boring AF' |
| Disaffected by juvenile content | Qs-G-Anon | 'Boring/childish' because 'it was easy and looked like it was designed for kids. Boring.' | 'Boring' because 'it's a boring task' | 'not do much cause their [sic] boring.' |
| | Qs-M-Anon | 'Annoying 'because 'It was aimed at Primary Schoolers' | 'unusual' because 'the year eights looks like they're year 5-6s' | 'be interesting because I would learn something' |
| Disaffected by computers | Qs-D-Anon | 'boring' because 'I don't like computers' | 'easy and boring' because 'the work is too easy and I don't like computers' | 'be filming videos and stop motion.' |
| | Qs-E-Anon | 'boring' because 'I didn't even log in cause it wouldn't work so I did nothing for entire lessons.' | 'difficult' because 'I couldn't log in I don't get the Scootle website.' | 'be the funner stuff like stop motion and all that' |
| Engaged | Qs-K-Anon | 'quite fun' because 'we got to do challenging stuff or things that are the same level as us' | 'pretty boring' because 'it would be easier work which isn't challenging.' | 'make me interested so I could get involved and concentrate' |
| | Qs-N-Anon | 'interesting' because 'it showed me different methods and ways for children to learn.' | 'challenging' because 'there are so many different functions on the program' | 'teach me how to differ between larger and smaller fractions and show me different ways to work this out.' |

*Note.* DLO = digital learning object; * Qs = questionnaire ($n = 15$); central letter in Qs-?-Anon (from A to O) denotes different student; Anon = anonymous response. Please refer to Appendix H to see these responses in context.

It appears about a quarter of the students thought the DLOs in Scootle were pitched at students below their ability (yet the DLOs have a selectable age range from kindergarten to Year 12), and rather than rejecting a DLO as not being age appropriate, it seems some students tended to experience the entire appraisal activity as a slight. From the 15 students who completed the questionnaire, four expressed this sentiment. Two of the four comments about this appraisal activity and the Scootle DLOs were, ‘It was aimed at Primary Schoolers’ and ‘it was very child-like’. The responses were sorted by apparent expressed theme: general disaffection ($n$ = 3); disaffection for juvenile content ($n$ = 4); disaffection for the computer element of the task (e.g., ‘I couldn’t log on’ and ‘I don’t like computers’; $n$ = 4); engagement ($n$ = 3) and one was unclear. As can be seen from Table 6.3 with two representative questionnaire responses for each theme, most seem to show disaffection with the task, but there was a range of responses.

Not all students appeared to dislike the activity. Some students were able to navigate around the site, explore it and land on DLOs of interest, stating, for example, it was ‘quite fun’ because ‘we got to do challenging stuff or things that are the same level as us’ (Qs-K-Anon) and another student wrote it was ‘alright’ because ‘we could visually see stuff’ (Qs-L-Anon). Please refer to Table 6.3 to see a summary of responses. So, it appears some participants were not affronted by the DLOs designed for younger students, and simply moved on to find those DLOs that suited them. On the other hand, only one pair handed in a DLO appraisal sheet and most students seemed to be disaffected by the task.

Suggestions of DLOs for the students to appraise were included on their appraisal sheet given to them which ranged from below their level (Year 5 and 6) to at their level (Year 7 and 8) for two reasons. Firstly, it was planned that less able students would have a chance to play with the interactive activities and learn from them with an ostensible reason to engage that would allow them to perhaps avoid peer humiliation (e.g., thinking perhaps, ‘I have to appraise this, so others won’t think I need it if I engage with it’).

Secondly, it was planned that the students would discuss in groups which DLOs to include into the module and which ones to reject and why. This may have been, in hindsight, a mistake. For example, one of the DLOs, Fraction Fiddle, an interactive tool comparing fractions, had an annoying, forcedly cute, bouncing animated figure that pointed to instructions. Even the name, Fraction Fiddle, would perhaps appeal only to younger students. From the students' pre-test results (please refer to Appendix J for the pre-test and Appendix K for pre-test results), it appeared that some students were yet to understand how to visualise and compare fractions. So, the mathematics of Fractions Fiddle might have been an excellent tool for them. For others it might have been fun to try to work out and then have visual confirmation of some harder fraction comparisons (e.g., what is bigger 10/7 or 15/11?). Admittedly, it is possible that these students were not reacting to psychological undercurrents but simply did not pay attention to instructions and missed that there were other DLOs to explore. However, it appears the graphics and animation were not suitable for this age group, and the juvenile-looking content may have turned the students off even appraising the DLO, let alone using it themselves, or worse still, considering putting a link to it in a module for peers to use.

In the questionnaire administered in Lesson 10, the students were asked retrospectively to state what they thought about appraising the DLOs for Year 5 or Year 6s instead of Year 8 peers. It was thought this might help protect students from the rigours of social and academic comparison with peers and help them engage in the appraisal without seeing it as a personal affront. This appears to have somewhat alleviated that negativity for one student: this would be 'an effective tool' because 'it is at their level of smartness'. However, on the whole it simply was not received as a relevant and worthwhile activity for the Year 8 students as these three illustrative responses seem to demonstrate: (a) 'it's for year 5 to 6 students so I wouldn't like it'; (b) 'the year eights looks like the year 5-6s'; and (c) it would be 'boring' because 'It would be easy for me as a year 8, year 5s and 6s should assess it'. Please see Table 6.3 to see these quotes in context with other quotes. Furthermore, it appears that some students might not want to be seen doing it.

It is possible some in the group may have felt their abilities and level of sophistication were being underestimated by exposing them to learning objects designed for younger students. Also, it appears that there was a barrier, perhaps the perceived affront of being infantilised (despite being asked to look for this from a course creator's perspective), which prevented some students from taking the opportunity to explore, learn and challenge themselves in this activity. On the other hand, by not receiving direct feedback on their level of understanding via their marked pre-tests, it seems plausible that students thought their mastery of fractions was complete. It is also possible there were simply too few DLOs that appealed to this group. However, there appears to be a consistent theme of students being unwilling or unable to take on adult or teacher-like roles.

It is possible that my assumptions indicate a weaker alignment with a student-centred ideal than planned. Li and Ma (2010) found by meta-analysis of 46 studies that computer technology positively impacted mathematics education through, among other factors, a constructivist, rather than traditional approach. Attard and Northcote (2011) discussed that to support engagement in mathematics, technology in the classroom should be student-centred and driven by the pedagogy, not the other way around. Although planned to be contructivist and student-centred, it appears asking students to appraise DLOs in Scootle for peers undermined rather than supported their psychological or social needs. In this way, the activity was not student-centred, but assumption driven. The assumptions which drove the choices for this part of the module creation, that students would like taking on a teacher-like role, would appreciate the opportunity to play with juvenile resources if given an excuse and would simply enjoy appraising digital learning objects, were seemingly unsupported with this cohort of students, and therefore were not as student-centred as planned.

In mathematics education, Martin et al. (2012) showed that enjoyment was one of the strongest determinants of student engagement. In this study, it appears many students were not enjoying the planned activities. Hamm et al. (2014) and Martin and associates (2012) found that the perceived classroom level of engagement affected individual students' engagement, so it appears that if personal enjoyment was low and perceived class engagement was low, then this would likely engender a spiral of disaffection. This perceived cast of disaffection certainly did not appear to be helped by the problems encountered with using computers.

## 6.7 Unexpected Reactions to and Issues with Computers

This project was planned assuming that students would enjoy working with computers and that using computers would help them engage in their study of mathematics. These joint assumptions appear to be unfounded on two accounts. Firstly, some students flatly stated that they did not like computers, and secondly, using computers, especially when connecting to the Internet with the school networked computers and trying to log on to password-protected websites or software, was generally problematic and as such, was largely not engaging. Computer use in the classroom was often problematic. There were five types of problems: (a) computers were not of interest; (b) computers taking a long time to warm up; (c) frustrations in logging in; (d) some students not knowing how to use software; and, (e) some students apparently navigating away to play games or search the internet rather than completing the lesson's aims.

**Computers are not, by themselves, engaging — but have their benefits.**

In answer to the prompt in the questionnaire about selecting digital learning objects (DLOs) for younger students on Scootle, two students replied that the task would be boring because 'I don't like working on computers' and 'the work is too easy and I don't like working on computers'. Please refer to Table 6.3. Considering this question was not specifically asking about computer work, this was followed up in the focus group discussion. In answer to the question, 'What can you tell me about choosing learning objects in Scootle?' (Focus group discussion; 2017, October 26; 4:15) the responses were all negative regarding physically accessing the website: 'It didn't work for me… I couldn't log in or anything' (Kate); 'Yeah, I forgot my password' (Jacob); and 'It disliked me' (Toby). The logging in problems are discussed further under section 6.7 Unexpected Reactions to and Issues with Computers; sub-section ‘Logging in log jams’. Please refer to Table 6.4 to see these and other quotes in context.

Kate seemed convinced that computers were often, or even always, problematic. For example, when the focus group students were asked how they would feel if walking into class they were told they were going to be using computers, Kate quietly stated (only heard on playback), ‘I’d feel like walking back out of the class’. Others seemed more positive. When asked about using computers in general, Toby said, ‘It’s better than writing’ and intimated with gestures that writing with a pen and paper was more tiring than using a computer, ‘You can just type in like that [motioning hands typing] ... You just press it’. Siobhan said, ‘It’s faster than writing,’ and Lissy said, ‘Less mistakes than when you’re writing’. In contrast, Kate said, ‘They never work for me… They always stuff up’ (Focus group discussion; 2017, October 26; 4:10 to 7:15). Please see Table 6.4 to see these and other responses regarding computer use in context.

It seems that, counter to my expectations, many of the students were not very experienced in accessing the Internet with the school computers and had not accessed many or perhaps any password-protected websites prior. At least two students (Kate and one other anonymous student) seemed worryingly averse to using computers in general. Furthermore, some students did not seem to demonstrate expected levels of computer skills and knowledge with the programs Paint and PowerPoint. There appeared to be a willingness from some students to blame the technology for not working rather than investing in understanding how to solve any access, or other, computer issues. Conversely, it seems that, in line with my expectations as a researcher, students were largely adept at using computers for writing and that using computers helped them write fluently and accurately.

Table 6.4

*Engagement with Learning Activities Using Computers: Typical Responses*

| Lesson no. (L)<br>Activity description | Source | Condition or prompt | Computers engaging<br>Participant; time | Computers not engaging<br>Participant; time |
|---|---|---|---|---|
| L 2 & 4. Looking at and appraising DLOs in Scootle | Q'aire | I found looking at Scootle learning objects for Year 8s… | 'quite fun' because 'we got to do challenging stuff or things that are the same level as us'<br>Qs-K-Anon | 'boring' because 'I don't like working on computers'<br>Qs-D-Anon |
| | Focus group | Tell me about choosing learning objects in Scootle | | 'I forgot my password'<br>Jacob; 5:30 |
| L 7. Gauging area — putting grid overlay on amorphous shape in 'Paint' | Exit Slip | I was most engaged when I was… | 'On the computer doing the overview [sic: overlay?]'<br>Isabella | |
| L 9. Making digital animation — dividing circle and number line into smaller unit fractions (the one computer-based activity of four 8-min activities in rotation) in 'PowerPoint' | Exit Slip | I was least engaged when… | | 'Computer stuff'<br>Ex-L9-5/17-Anon |
| | Video | | Students at computers leaning forward; looking at and touching screen; making measurements<br>Lissy; 0:36 to 6:29<br>Toby & Zach; for 4:04 | Student on a wheeled chair circling around, often flopping backwards looking at ceiling<br>Nicole; 7:55 to 15:02 |
| | Video | Some networked computers slow to warm up | | Computer took 3:55 to warm up. Students inactive<br>Ryan & Sam; from 2:27 |
| L 13. Focus group discussion | Focus group | What can you say about using computers in class in general? | '…faster than writing'<br>Siobhan; 6:45<br>'Less mistakes than when you're writing'<br>Lissy; 7:30 | 'They never work for me… Nah, they stuff up all the time'<br>Kate; 6:05 |
| | Focus group | If you were told your class were going to work on computers, what would you think? | | 'Yay. We get to listen to music' Toby; 6:25<br>'I'd feel like walking back out of the class'<br>Kate; 6:30 |

*Note*: DLO = digital learning object; Scootle = repository of DLOs; Q'aire = questionnaire; L = lesson

When I asked Serena about why she did not use computers much in her classes, she said that she could see they were useful, especially for projects, but she did not like using them often in the classroom. When pressed, Serena said her approach was more traditional, she found using technology challenging and furthermore she felt that computer use in junior classes introduced classroom management issues that are not present with a pen and paper approach:

> I'm not technologically that advanced. I like [students] to use it as a learning tool, but… I think half of the class will not make [use of computers] in an effective and a responsible way. Like, some boys will just go onto computer games; otherwise we need to observe them each and every [unfinished]. I booked the computer room just for some projects or something, that's it… But most of the days they work just the traditional way. They work with their book and paper, and book and pen. (Teacher interview; 2017, 20 December; 29:30 to 31:10)

In senior classes, where Serena told me at Rivertown HS students have one-to-one computer laptop access and use computer algebra system (CAS) calculators extensively in mathematics, Serena noted that the students are more mature and use technology productively to further their learning: ‘In Year 11 and 12, they're really responsible adults. So, they don't have time to play with it’ (Teacher interview; 2017, December 20; 35:12). Furthermore, Serena wanted students to be adept with both pen and paper and technology: ‘…in Year 12 they are not going to use computers for the final exam’ (t = 32:00). So, Serena was not averse to using computers in the class, but that computer use, although worthwhile for projects, was often problematic in junior secondary classes and more productive in senior classes. Serena was keen to prepare her classes for life and examinations by emphasising book, pen and paper tasks in studying mathematics.

**Networked computers**

The school had one computer room, which Serena booked for each of the sessions. There was often a 3-minute or even longer delay while waiting for the log-in screen to appear (please refer back to Table 6.4). While waiting, the Year 8s would use the wheeled chairs as vehicles to scoot across to their friends and chat. It then took time to refocus the group while they were reminded of tasks, and invariably one or two computers were still warming up which meant re-explaining the tasks again to the students using those computers. The momentum of the lesson was lost and had to be recaptured. In a 48-minute lesson, this was an apparent, large, distraction-evoking, boredom-inducing delay. I wondered if this was the usual case with networked school computers. Certainly, I could have managed the wait time better with, for example, class discussions and mini problems to solve while the computers were warming up. Perhaps class monitors could have been asked to start the computers at the beginning of the lesson. However, regardless of better ways to handle this, the time delay in being able to use the networked computers was still a problem, but not the only difficulty.

**Logging in log jams**

Analysis of the researcher journal, teacher interviews, students' questionnaire responses and video evidence, shows there were problems in trying to get the students to log in to Scootle and the hosting site for the e-learning module. Serena was not an advocate of using computers in junior secondary classes except for occasional projects, but I thought the students would be accessing the internet and password-protected websites in other subjects and therefore used to logging in regularly. This assumption appears to have been false. Perhaps it was a ploy to misbehave, but many students genuinely did seem to forget their log in details to access the internet. 'What's my username?' 'I can't remember my password,' was heard for about five minutes while Serena and I passed around the sheet of usernames and passwords.

Indeed, the logging in problems were so time consuming that Serena seemed surprised that any students logged on for the first session:

> Most of them couldn't do it actually because they couldn't log on the student number and the… What is it? Student email or whatever it is. It was not working. I don't think anyone could do it. Do you think anyone could start? (Teacher interview; 2017, May 12; 21:50)

For the first internet activity, students were assessing digital learning objects on Scootle. As well as waiting for the networked computers to warm up and accessing the Internet, the activity required creating and registering an account with an email address and a password. 'What's my email address?' was the next question for the next five minutes. Students needed to put their username at the beginning of their school's email address string; e.g., username@rivertownhs.vic.edu.au (this email string has since changed to username@school.vic.edu.au; teachers and other employees have a different email address configuration). Some students muddled the vic.edu part of the address, forgot a dot or two, left off the 'hs' (for high school) or spelt the name of their school (and town) incorrectly. Once the email address was correctly entered, students needed to access their emails, and then open and respond to the verification email from Scootle. Some students did not seem to understand that if the email string was correct and they successfully entered their password, they could indeed log on to Scootle. 'I couldn't log on,' wrote one student in the questionnaire. 'I didn't even log in 'cause it wouldn't work so I did nothing for entire lessons,' wrote another.

These problems seemed to be exacerbated when students were trying to log into the hosting learning management system (LMS) software[4] for the e-learning module. The benefits in using the LMS which was designed for teachers to upload, share and select interactive content for their classes were considerable: a platform to display content including capability to display mathematics equations and symbols; tools to create and assess formative quizzes and summative tests (including true/false, multiple-choice, ranking, matching and short-answer questions); and tools to create word searches and competitive races. Students were to have access via two roles — one of four 'teacher' roles (one for each group) in charge of content to upload, create, rearrange and delete; and one each as a student. Students needed new usernames (in their student role using their actual names married

[4] I have deliberately not divulged the name of the learning management system hosting the e-learning module because it was not successfully used in this study. However, it was employed in a manner for which it was not designed. So, I would prefer not to give it unfair negative exposure.

with a new bogus email address) and passwords. Each student in their student role had the same password, so that part was easier.

There were two attempts for students to access the LMS, one early in the project and once at the end. For the first attempt, a few students did manage to log on in their student role, but the aim of that part of the lesson was not met due to logging in issues of their classmates. The plan for students to take turns to log in with the teacher role was dropped; it was too difficult to manage the different roles and for students to even gain access. In Lesson 12, after the post-test, students tried to gain access again. Eight of the 13 students present that day did not successfully log in. Two did not appear to attempt to do so and six tried (those latter six instead attempted to create videos showing the relationship between a rate, speed, and fractions using a marble launched down a variable slope). Of those five who did gain entry, only three students successfully completed the learning task, to compete in a fractions-comparison challenge race. At least one of the two students who did gain entry to the LMS, but did not take part in the race, appears to have navigated to a game site instead (see below). The classroom screen would not connect with my computer that day, so I could not show the e-learning module content I had uploaded or the race.

I can imagine such mini-dramas playing out in other classrooms with students that are not used to using networked computers to gain access to the internet and password-protected websites regularly, with teachers, like me, not used to pre-planning to avoid such problems like the ones I encountered and helped create, and teachers very experienced in other means of teaching, like Serena, giving up.

Zuber and Anderson (2013) found that both cautious and non-adopters of technology tended to believe technology (in their study, laptops) in mathematics classrooms aggravated classroom management issues, especially for lower-achieving students. Outside of the bounds of this study, Serena was not an advocate for regularly using technology in her junior mathematics classes. As discussed by Pierce and Ball (2009), mathematics teachers will seek to adopt and integrate technology in their classroom if they can see a benefit. Serena readily used computer algebra systems (CAS) calculators in her senior mathematics classes but reported only using computers in her junior classes for projects. Unfortunately, the experiences in this study may have served to underscore her choice not to use technology more broadly. Attard and Northcote (2011) reason that the pedagogy should drive the technology, not vice versa, so if Serena was to include more technological innovations in her class, which was not the focus of the study, then her rather traditional, direct instruction pedagogy, which I saw being warm, predictable and effective, would need to embrace the change first. Drawing on EVT, then the necessity and benefits for altering her pedagogy and adopting more technology would need to outbalance the costs (presumably time, effort, the psychological effort of making change and the fear of giving up expertise, the comfort of routines that work) and her perception of the likelihood of success would need to be high.

**Students' information technology skills**

I was surprised how limited some students' information technology skills appeared to be. For example, many students did not seem to have had experience in formatting within PowerPoint (however, some students were adept); had not used the snipping tool in Microsoft Office; and did not know how to copy and paste or make transparent selections within the program Paint. Mini how-to videos were created that the students could access offline as needed in the classroom, but it was difficult to run this project and train the students at the same time. For example, students in pairs or triads were asked to create sets or shapes which would be challenging for Year 8s to ascertain the equivalence or comparative magnitude; only one triad managed to produce a suitable image; please see the students' image in Figure 6.1. At first, some students needed help to think of challenging shapes, amorphous areas or sets to compare (e.g., what would be a bigger proportion, a set of 4 out of 7 or a set of 6 out of 11?) but then could not seem to work out how to depict this and needed to be shown how to copy and paste and make either transparent or opaque selections. Stopping to teach what I assumed would be known made it difficult to both develop momentum for the project and to allow the students to demonstrate competence; this may have had a bearing on the engagement of the group.

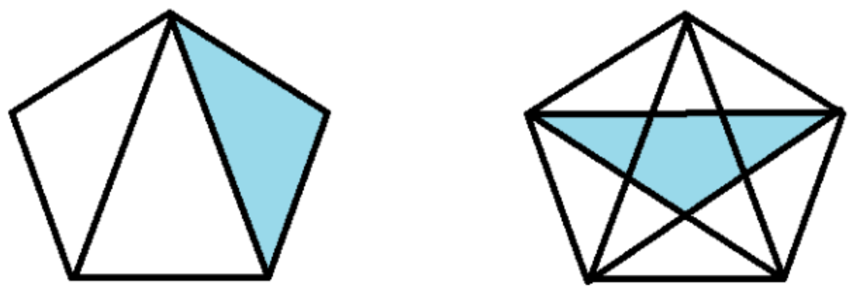


*Figure 6.1.* Are the shaded areas equivalent? The only successful student-generated image of shapes for challenging equivalence, created in the program Paint

**Students wanting to play games instead**

The video evidence from across the lessons showed two occasions when some students appeared not to be engaged in the aims of the lesson, but rather had navigated to other sites on the internet or were online playing games. It was not possible to determine from the video evidence, due to the placement of the classroom cameras and synching problems when shooting a computer screen with a digital video camera, whether these instances were the only ones or exactly how many students were on non-target sites. In the first instance, there was audio evidence only when the presenter (me) was speaking: ‘I can see some work there that's nothing to do with what I have asked you to do. So, if you could shut that down, that would be great’ (Video of Lesson 3; 2017, May 5; 7:33). In the second instance, at the far end of the class away from the camera, the recording shows coloured shapes moving across a screen which are consistent with a student playing a game and not consistent with the activity’s aim of comparing the magnitude of fractions pairs in the LMS. This occurred while I was occupied with other students videoing the speed of a marble (Video of Lesson 12; 2017, July 28; 0:08 to 16:02).

In both cases, within the lessons there were considerable delays with many students trying to log in to external websites, but data was not gathered to ascertain whether the students on other sites were bored by not being able to log in; had logged in but were waiting for others to catch up; were disaffected by the task itself once started; or had no intention of completing the lesson's aims and used an opportunity to pursue their own aims from the outset.

It is not clear whether students navigating apparently to game sites was an artefact of the conditions of the activities, a predilection of those specific students or a trend across the age group, the latter of which seemed to be the teacher's experience at that school. In Canada, Kay, Benzimra, and Li (2017) found that secondary level boys were more likely than girls to be distracted by playing games with bring-your-own devices in class but that the advantages outweighed the disadvantages and distractions. There appears to be very little literature on the incidence of students playing games on computers instead of completing their work and whether this is due to unengaging pedagogy, perhaps a show of deviant solidarity amongst disaffected youths (see Kosten et al., 2013), inappropriate implementation of technology or borne from students, perhaps within a milieu of societal acceptance of access to games and social media, expecting entertainment rather than attainment in education.

## 6.8 Discussing Findings through the Theoretical Framework for this Study

The theoretical framework of this study draws on expectancy value theory EVT (Eccles et al., 1983; Wigfield & Eccles, 2000), self-determination theory SDT (Deci & Ryan, 2000), and the control value theory of achievement emotions CVTAE (Pekrun, 2006). Expectancy value theory holds that students will engage in an activity if they perceive they will succeed, value the activity and the benefits in committing outweigh the costs in doing so. In Figure 6.2, EVT is depicted as the pink arrowed rectangle showing a choice between engagement or disengagement.

Self-determination theory holds that for humans to be intrinsically motivated to learn, three key psychological needs must be supported and met: the need for competency, interaction with others and meaningful, self-determining choices. It is depicted in Figure 6.2 as the dark grey elongated rectangle after the presentation of the learning activity (in orange), and in the background of the valuing of the goal, intrinsic motivation and engagement, representing that the three needs must be supported throughout the presentation, motivation and engagement processes on the trajectory towards the learning goal, and if any of the needs are not supported by the activity, the path will change to favour disaffection.

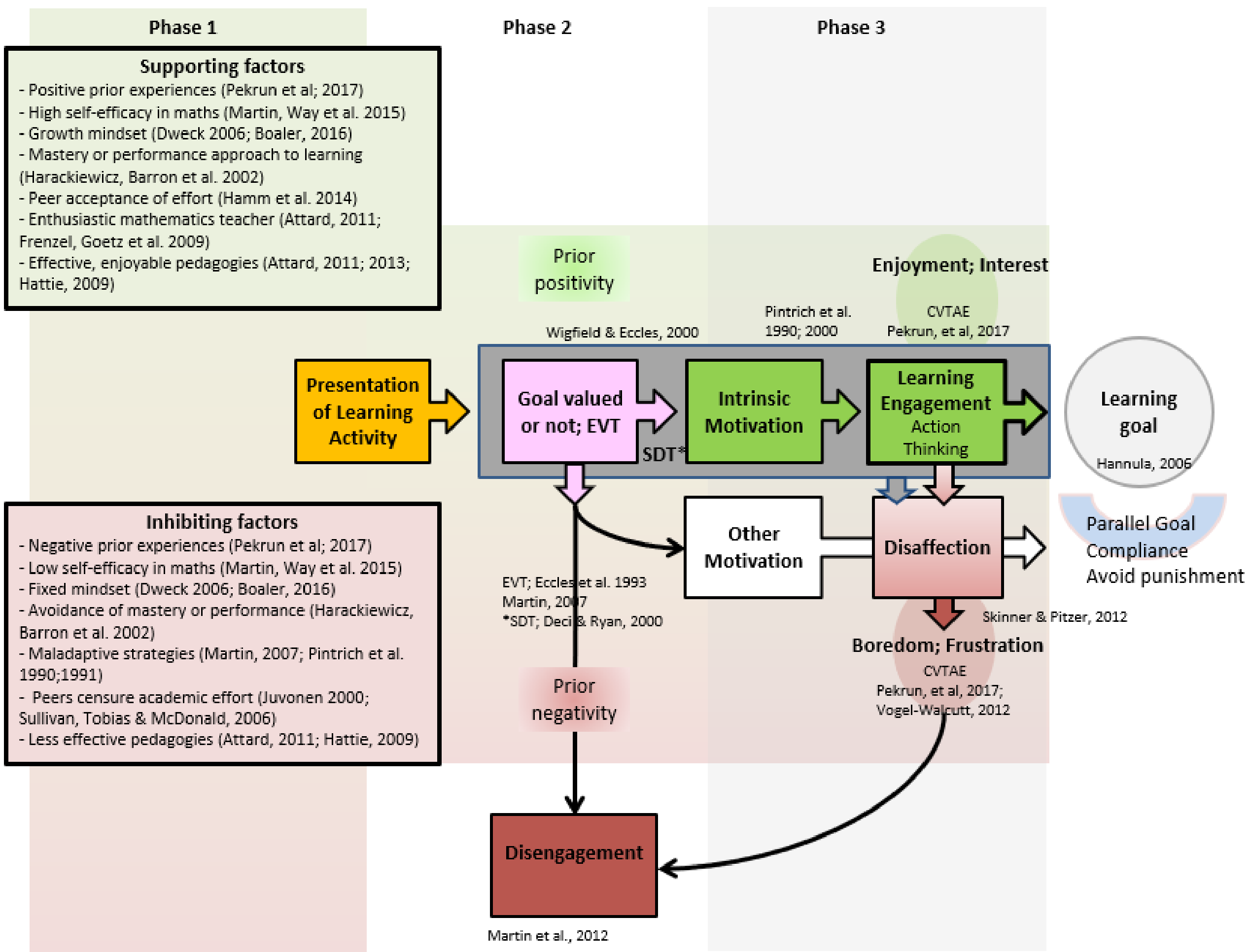



*Figure 6.2*. Theoretical framework of learning activity engagement and disaffection of early adolescents showing three phases: (1) Initial and ongoing supporting (green) or inhibitory (brown) factors; (2) Deciding to engage or not; and (3) Engagement with enjoyment and interest or disaffection with boredom and frustration.

The control value theory of achievement emotions holds that elicited emotions in achievement settings are either positive or negative depending on whether the students value the task or not, feel they can control the outcome or not, and whether the outcome, if of value, is successful or not. For Pekrun, the positive emotion elicited during learning activities (so during engagement) and signifying the student values the task and feels in control, is enjoyment, and this is associated with interest. Conversely, where students do not feel that they have control or do not value the task, the negative emotions of boredom and frustration are elicited in a state defined here as disaffection. In Figure 6.2, the achievement emotions as described by CVTAE are depicted as balloons above (positive) and below (negative) of the engagement trajectory towards the learning goal.

As discussed in Chapter 3: Influences on Engagement, there are multiple factors reported in the literature which either support or inhibit learning engagement. A number of the major factors, for example, prior experiences (Pekrun et al., 2017) and mindset (Dweck, 2006), are depicted in Figure 6.2 on the left-hand side and across the centre of the graphic, in a cast of light green (supporting) and brown (inhibiting), proposing that they pre-exist before the learning activity is presented to the student and may influence throughout the decision, motivation and engagement phases.

Some of the background factors in this study which may have impacted on the students' level of engagement and engagement decisions appear to be the time of day the lessons were conducted (last period on a Friday when the students appeared to be tired); having some students in the class apparently anxious about testing; having many class members presenting with apparent entry level skills and knowledge in ICT; being in a streamed class (for literacy) which might have caused social tensions and comparisons between the different class members; and having just completed a term on fractions and decimals might have over-exposed the students to the same topic. It seems plausible that the testing anxiety some students appear to have suffered may have been influenced by the school culture, although it could have been from factors within individual students. It also seems plausible that the many negative events at the beginning of the project created an ongoing negative impact over the project for some students (Pekrun et al., 2017) and may have therefore affected engagement of the students. Regardless, these potential background factors plausibly hindered engagement and are represented in Figure 6.2 as a brown background shading.

Moving to Phase 2 of the graphic depiction of theoretical framework for this study, the decision-making phase of the theoretical framework is described by EVT. In this study, some of the fears and decisions reported to Serena by the students, and then relayed to me, seem to be able to be explained by EVT. Having peers at the same school assess the finished e-learning module would not be of value to the students and might threaten friendships if these Year 8 students took on an apparently unwanted teacher-like role. Also, it is possible that these advanced-group, streamed Year 8 students enjoyed a special academic status at the school, so it would not be of value to have that status challenged with any inadequacies exposed. Thus, it appears the affected students chose not to engage and work towards the learning goal as presented. Indeed, only when the particular goals were removed, creating assessments with and for peers and having the projected e-learning assessed by known peers, did some students seem to be appeased and could consider engaging with the next activity. Interestingly, in keeping with the expectations of CVTAE, the students' emotions expressed (as retold by Serena) were apparently of anxiety and apprehension and not those of the active phase: enjoyment, interest, boredom and frustration.

The theoretical framework of well-research theories also seems to explain events when students assessed digital learning objects (DLOs) in Scootle. Asking this cohort of Year 8 students to select DLOs for other Year 8 students did not seem to engage most of them and was fraught with technical difficulties. Furthermore, it appeared to play on rather than assuage their vulnerabilities and the activity did not seem to satisfy their psychological need to been seen as competent (Deci & Ryan, 1985; Deci & Ryan, 2000; Deci et al., 1999). According to expectancy value theory (Eccles et al., 1983) — which holds that students will engage in an activity if they see the benefits, see no or few costs and appraise their chances of success as high — it appears that for some students there was a perceived social cost in engaging with the activity — perhaps being seen as juvenile or as having juvenile tastes. It appears that asking these Year 8 students to assess DLOs for younger students did not give them an ostensible excuse for engaging in the content whilst being saved from embarrassment. Rather, the data suggest it was perceived as an irrelevant, dull or juvenile task by most of the Year 8 students. So, again, students chose not to engage.

Some students expressed an unexpected tendency to dislike working with computers. This could perhaps be represented in the graphic depiction of the theoretical framework as a background factor which negatively impacted engagement throughout learning tasks which involved computers. Some students seem to present with entry level ICT skills. This also could be represented as a background hindrance although, under SDT, perceiving oneself as competent is a need which must be supported for a student to intrinsically engage in a learning activity. Not enough data was gathered on this issue to know if students perhaps learnt ICT skills during the study or it was a factor which affected engagement in some activities and in the overall project in creating an e-learning module on fractions. I suspect the latter.

### 6.9 Concluding this Chapter

In this chapter, I explored what happened when my assumptions as researcher, which undergirded the study, met with classroom realities. I explained that the initial, overall project goal for this study shifted such that the students did not complete an e-learning module on fractions for peers. The lack of momentum from a range of factors, stemming from researcher assumptions and situational factors, seemed to have not only stalled the production of the e-learning module, but affected the engagement of the students. The situational hindrances were the following: (a) the study was conducted last period on Friday when some students appeared tired; (b) there seemed to be a mismatch between the technology use level needed to execute the project and that of the students; (c) some students seemed to exhibit strong anxiety about testing; and (d) the class had already spent a term on fractions and decimals prior which may have been overloading them with the same topic. However, seeing what happened when my researcher assumptions met with realities in the students' classroom inadvertently uncovered some interesting findings.

The first researcher assumption was that students would be engaged by peer-to-peer assessments and it would position them as experts in what fellow adolescents would need and like. Rather, peer-to-peer assessments seemed to play on the students' fears and undermine their social need for acceptance, belonging and support. Another activity planned to be engaging but seemed to be mostly the opposite was appraising digital learning objects in Scootle. An intriguing finding was that some students seemed to be disaffected by juvenile content regardless of context and seemed unable or unwilling to take on an adult role. It is not known if this was a face-saving and relationship-protecting measure in that the students did not want appear to be putting in too much effort to peers to take on a teacher role that might be seen as ingratiating themselves to teachers, so competing for attention (Juvonen, 2000). Or perhaps these students had a heightened sensitivity towards juvenile content and wanted to distance themselves from it appear more grown up and competent (the latter being one of the three psychological needs of self-determination theory), regardless of the context. On the other hand, this exploratory data can be challenged in that perhaps some students simply did not pay attention to instructions, only assessed the first suggested DLO (which had juvenile graphics) and based their appraisal of all DLOs and the activity on that one appraisal. Finally, this finding also poses the question of whether suitable digital learning objects for these Year 8 students were in Scootle that would help them with their exploration of fractions in an empowering, rather than infantilising, manner.

A final finding discussed was that using computers in themselves were not, as assumed, engaging of themselves. Some students seemed to have a predilection against computers and others seemed inexperienced in information technology. Also, there were some issues with networked computers and in students logging in to password-controlled websites.

Self-determination theory holds that one of the components of engagement is that the need for competence is supported. The findings discussed thus far in this study suggest that students were not able to demonstrate competence in some of the areas which were erroneously assumed they would excel: (a) knowing and expressing the needs of peers for assessment; (b) the same for selection of digital learning objects for peers; and (c) use of technology. It seems plausible that the milieu of situational factors and assumption-driven activities that largely failed to engage the students may have contributed to seemingly widespread disaffection amongst the students. Disaffection is explored in the next chapter.

# Chapter 7: Disaffection — Expressions of Boredom

This is the second of three results and discussion chapters. In this chapter I discuss what activities, activity characteristics or conditions appeared to be disaffecting for the students, specifically those that seemed to be boring for them, and I explore what might be behind those responses. I also discuss ostensible instances of students rating lessons poorly for engagement in contrast to video evidence suggesting otherwise.

## 7.1 Signposting this Chapter and Background

The findings are discussed in four sections: (a) boredom as a frequent theme; (b) apparent boredom when content was seemingly not valued; (c) apparent pedagogical-based boredom; and (d) persistently expressed boredom.

In section 7.2 Boredom as a Major Theme, I examine the most frequent words used in the two sources of written responses from the students: the questionnaire and the exit slips.

In section 7.3 Apparent Boredom from Not Valuing Content, I explore evidence found in both the questionnaire and exit slip responses which suggest that some of the apparent disaffection from the students stemmed from not valuing the content and perceiving it as too easy. I question some of the students' stated perceptions but find support for others.

In section 7.4 Apparent Pedagogical-based Boredom, I examine the evidence which suggests much of the early pedagogy was experienced as too passive for the students. I then compare exit slip responses to the video evidence and discuss apparent alignments and contradictions. I consider the perspectives of the two teachers, the expert mathematics classroom teacher, Serena, and myself as the researcher/presenter.

In section 7.5 Persistently Expressed Boredom, I discuss instances where some students' responses seem to communicate boredom despite evidence of engagement in some learning experiences.

Here, as for the previous chapter, Chapter 6: Classroom Tensions — When Researcher Assumptions Meet Classroom Realities, I draw upon self-determination theory (Deci & Ryan, 2000), expectancy value theory (Wigfield & Eccles, 2000) and control value theory (Pekrun, 2006) which together have helped me ponder and discuss student engagement and boredom the students. This is considered in section 7.6 Discussion of the Findings through the Theoretical Framework for this Study.

**Background**

Despite wanting to study engagement and pre-supposing I had planned activities which would be enjoyable, many students reported that a range of activities, topics and conditions were disaffecting, and more specifically, boring. This was puzzling, but also offered an opportunity because I came to realise that boredom could not be ethically researched within a mathematics classroom with the aim of evoking it. It seemed to be possible that the study of these students' responses which indicated disaffection, the opposite to learning activity engagement, could potentially give insight into the learning and social needs of these early adolescent learners. Furthermore, I came to regard the collection and analysis of the different facets and experiences of boredom as worthwhile for helping me, and hopefully others, potentially identify and address some of the likely sources of the students' disaffection, and ponder the rest with curiosity, compassion and candour.

To understand the most salient sources of boredom which appeared to be elicited in this study, I looked for the most frequent instances in the students' written responses (mostly anonymous) to exit slip and questionnaire prompts where students stated that a condition or activity was boring or otherwise not engaging.

## 7.2 Boredom as a Major Theme

In this section, I demonstrate that boredom featured strongly in students' written responses and as such appeared to be a major theme in this study. The written responses were from the questionnaire ($n$ = 15), administered near the end of the study in Lesson 10 (Lesson 11 was the last full teaching session of the lesson sequence), and from exit slips ($n$ = 69 total), administered directly after five of the lessons. Most students elected to respond anonymously to the exit slips (please refer to Appendix B to see a copy of the exit slips used and to Appendix G to see all 69 responses). All students elected to respond anonymously to the questionnaire (please refer to Appendix C to see a copy of the questionnaire and to Appendix H to see the students' responses to each question). The questionnaire was devised during the study and ethics approval needed to be sought before administration. It canvassed responses from activities from Lessons 2 to 7 (Lesson 1 was a pre-test), but some students gave unsolicited mention of activities from Lesson 9 which involved student-produced videos and student-produced stop-motion animations.

Please note that the anonymity of all of questionnaire data and most of the exit slip data meant I could neither match responses across these major data sources for individual students nor correspond the written responses with the video evidence. This anonymity may have meant the students' responses were unrestrained and perhaps more honest. Regardless, I analysed the responses for prevalent themes and have found interesting patterns.

Once I establish that boredom seemed to be a major theme of this study, I discuss the questionnaire responses, then the exit slip responses, especially in relation to boredom, and identify what other themes seemed to emerge from the students' responses.

**Boredom seemed to be a major theme**

To initially gauge overall word response themes, the word-frequency facility in NVivo was applied to the pooled responses from the students ($n$ = 15) to the ten questionnaire questions (seven 'prompt-because' pairs [described below] plus three other questions). Each of these open questions was about specific activities or conditions, or asked about aspirations related directly to the study, so the responses gathered could be pooled without inherent bias to gain an overall picture of the themes. Table 7.1 shows the ten most frequent words from the student questionnaire responses.

Table 7.1

Word Frequency (Top 10) of Student Questionnaire Responses (*n* = 15)

| Word | Frequency rank | Count | Percentage (%) | Similar words included |
|---|---|---|---|---|
| boring | 1 | 46 | 6.0 | boring |
| learning | 2 | 21 | 2.7 | learn, learning |
| work | 3 | 19 | 2.5 | work, working |
| like | 4 | 17 | 2.2 | like, liked |
| easy | 5 | 14 | 1.8 | easy |
| know | 6 | 13 | 1.7 | know |
| fun | 7 | 12 | 1.6 | fun, funner |
| interesting | 8 | 12 | 1.6 | interested, interesting |
| fractions | 9 | 10 | 1.3 | fraction, fractions |
| different | 10 | 9 | 1.2 | differ, different |

*Note.* In total, 765 different words (thematic and otherwise) were collected in response to the 10 questions of the questionnaire which surveyed students' responses to activities from Lessons 2 to 7.

As can be seen from Table 7.1, the most frequent word used by the students when responding to the questionnaire about the content and activities as presented in the study to that point was 'boring'. In concert with this presentation of the data, when all the questionnaire responses were sorted into themes, over half, 58%, seemed to be expressing disaffection, particularly boredom. This seems to suggest that many students thought that many of the study's activities surveyed in the questionnaire were boring and this is discussed in section 7.3 Apparent Boredom from Not Valuing Content. About a quarter, 26%, of the total questionnaire responses appeared to be expressing engagement with learning. Apparent engagement is discussed in Chapter 8: Engagement – 'the funner stuff like stop motion and all that'. A further 8% seemed to be expressing slight or neutral engagement, for example, in regard to appraising digital learning objects, 'it was alright' because 'we could visually see stuff' (Qs-L-Anon) seems to be demonstrating mild or potentially compliant engagement. A final 8% of the total questionnaire responses were left blank or were un-codable, for example, when students stated they were not present for an activity. Please see Figure 7.1 for a visual representation of these proportions.

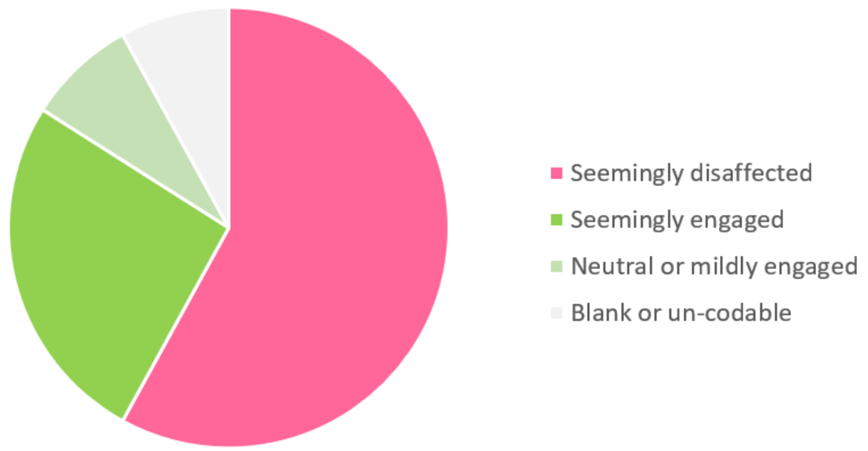



*Figure 7.1.* Proportions of student questionnaire responses seemingly disaffected, engaged, neutral or slightly engaged, and blank or un-codable.

The other source of written responses from the students was from the exit slips administered at the end of five of the lessons. A total of 69 exit slips were gathered. The responses to the exit slip prompt ‘I was most engaged when…’ is discussed in Chapter 8: Engagement — ‘the funner stuff like stop motion and all that’. There were 63 responses in total for the exit slip prompt ‘I was least engaged when…’ (6 responses were left blank for that prompt). The more detailed disaffection themes arising from questionnaire and the ‘least engaged’ exit slips responses are considered in the next section.

**Disaffection themes from written responses**

Many of the instances where apparent boredom was expressed in both the questionnaire and ‘least engaged’ exit slip responses, the source of the disaffection was not further elaborated and was thematically categorised simply as ‘boring–no explanation’. For example, to the questionnaire prompt, ‘I found learning about the different concepts of fractions’, Qs-L-Anon wrote ‘boring’ because ‘I just did’. The frequency and application of some of these boring–no explanation responses seem relevant to, and are explored in the section on, seemingly persistently-expressed boredom. For example, Qs-A-Anon wrote that every activity queried in the questionnaire was 'boring' or 'pointless'. However, most of these boring–no explanation responses do not lend themselves to further interrogation and just add to the discussion of boredom as a major theme. Fortunately, many students did give extra information which could be categorised into more descriptive themes, and where possible, be checked against other data sources. Please refer to Table 7.2 for apparent disaffection themes from the questionnaire and to Table 7.3 for themes which emerged from the 'least engaged' exit slip data.

**Disaffection themes from the questionnaire**

As noted above, most of the total questionnaire responses were categorised as apparently expressing disaffection (58%). Within that category of apparent disaffection, the most prevalent theme was that of boredom with no or little meaningful explanation as to its source, with 17% of the total questionnaire responses. Please refer to Table 7.2. The next most prevalent theme, accounting for 11% of the total questionnaire responses, was that of content being seemingly already known, too easy or repetitive, and nearly all of these included the word 'boring' somewhere in the 'prompt-because' response. To illustrate, Qs-E-Anon wrote in response to 'I found learning about the different concepts of fractions…'. 'boring' because 'I learnt about that in like grade 4'. The theme of content being already known, too easy or repetitive is explored further in section 7.2 of this chapter.

Nearly one tenth, 9%, of the total questionnaire responses expressing apparent disaffection have already been discussed in Chapter 4: computer problems (5%), that is, both situational hindrances with and apparent predilections against computers; and students apparently feeling infantilised or finding the content childish when appraising DLOs in Scootle (4%). A further 13% of the total questionnaire responses with disaffection themes seem to show low levels of valuing the content: appraising content as pointless (5%), irrelevant (5%), or just not fun (3%). Not valuing content is also discussed in section 7.3 Apparent Boredom from Not Valuing Content.

The remaining other seemingly disaffected responses included the following: (a) students expressing problems working in groups, 3%, (e.g., ‘at times I was the only one doing work’, Qs-N-Anon); (b) students reporting not liking the conditions of the study, 3%, (e.g., we should just learn normal math, by the book and that it [is?] nothing weird’, Qs-F-Anon); (c) finding some content too difficult, 3%, (e.g., ‘difficult/boring… I didn’t get it’, Qs-D-Anon in reference to Pythagoras theorem); and (d) wanting more choices, 1%, (e.g., ‘letting us pick groups’, Qs-C-Anon). Although interesting, these last four minor themes are not discussed in detail.

Table 7.2

*Seven Themes of Apparent Disaffection from the Questionnaire*

| Main Theme | % of total | Illustrative example (response… because) | Topic or activity | Student |
|---|---|---|---|---|
| Boring–no explanation | 17% | stupid… it was boring | Fractions concepts | Qs-A-Anon |
| Content already known | 11% | boring… I learnt about that in like grade 4 | Fractions concepts | Qs-E-Anon |
| Computer problems | 5% | boring… I don’t like computers | Assessing DLOs for Year 8s | Qs-D-Anon |
| Irrelevant | 5% | boring… it's not my problem | Difficulties with fractions | Qs-D-Anon |
| Pointless | 5% | useless… it seemed pointless | Assessing DLOs for Year 8s | Qs-A-Anon |
| Infantilising or childish | 4% | boring/childish… it was easy and looked like it was designed for kids. Boring | Assessing DLOs for Year 8s | Qs-G-Anon |
| Not fun | 3% | not engaging… I didn't really listen, and it wasn't fun, and I was talking so I would block out the boringness | Benchmarking with fractions | Qs-J-Anon |

*Note.* Percentages refer to total percentages from the questionnaire. DLO = digital learning object

In this study, other written responses from the students were elicited from exit slips. From the exit slips, six themes, plus ‘other’ and ‘no answer’, which appeared to show disaffection were identified from the responses to the exit slip prompt ‘I was least engaged when…’. Please refer to Table 7.3.

Referring to Table 7.3 below, two ‘least engaged’ exit slip response themes were more frequent than all other categories: where students stated they were bored (30%) and where students stated they were least engaged when there were passive learning activities like ‘teacher talking’ and ‘watching the videos’ (28%). The disaffection theme found in the exit slip responses seems to corroborate the finding from the questionnaire suggesting that the students were bored for some or many of the activities.

The other major theme from the ‘least engaged’ exit slip responses was surprising: passive learning. Disaffection with passive learning was not evident in the questionnaire and will be discussed below in section 7.3 Apparent Boredom from Not Valuing Content. Other themes which appeared from the exit slip responses to the prompt ‘I was least engaged when…’ are that of distraction by others (9%), working or not working (6% and 9% respectively) and computers (7%). The theme of distraction by others included general classroom distractions, for example, ‘people were talking’; ‘it was loud’; and ‘people made noise while making the video’, as well as quite specific interactions, for example, ‘Mr Cork[5] yelled at me’; and ‘the dice were handed to me’. Although interesting, distraction was not a theme found in other data sources (questionnaire, focus group discussion, teacher interviews or researcher journals) and its duration, impact on engagement and contribution to disaffection appears unclear, and so it is not discussed in detail. For exit slip data which appear to be aligned with a distraction theme, please refer to Appendix G noting responses filled in yellow. The themes of working and engagement are discussed in Chapter 8 and the theme of computers being a source of disaffection was discussed in Chapter 6. The relatively minor theme of working being a source of boredom is not discussed in detail.

[5] Pseudonym; casual relief teacher in Lesson 7 on 2 Jun 2017.

Table 7.3

*Themes from Exit Slip Responses (*n *= 63) to 'I was least engaged when…'*

| Theme | Percent of least engaged* | Illustrative response of least engaged when… |
|---|---|---|
| Boring–no explanation | 30% | 'it was boring' |
| Passive learning | 28% | 'teacher talking' |
| | | 'watching/listening' |
| Not working | 9% | 'not doing my work' |
| Distracted by others | 9% | 'people were talking' |
| No answer | 9% | |
| Computers | 7% | 'Computer stuff' |
| Working | 6% | 'doing work' |
| Other | 3% | 'couldn't understand' |

*Note.* * Rounded percentages do not add to 100%. The 63 responses have been pooled across five lessons.

It is of note that the exit slip prompted for when students were least engaged, not when bored, so the 'least engaged' exit slip responses are not necessarily an indicator of boredom. Across the lessons, some students (18 of the 69 total responses; 26%) self-rated that they were either engaged for most (rating of 4; $n = 12$) or all or nearly all of the time (rating of 5; $n = 6$) but still recorded a response for when least engaged. This seems to indicate a capacity of these mostly engaged students to be somewhat disaffected in a lesson, but for that not to affect engagement overall. For example, one student with a SR for engagement of 5 wrote that he/she was *least* engaged when 'We watched the videos' but confoundingly also wrote that it *helped* her or him learn when 'I watched the videos' (Ex-L7-13/14-Anon). Therefore, it appears when some students self-rated a higher engagement level overall for a lesson, writing a response for when least engaged does not seem to equate with being bored or otherwise disaffected or not engaged in learning. Conversely, as might be expected, it appears a low self-rating of engagement for a lesson was often associated with themes of boredom, disaffection and seemingly lower SR engagement in learning. Please refer to Appendix G which shows the exit slip responses ranked and sorted according to SR level for engagement, then SR level for learning level.

## 7.3 Apparent Boredom from Not Valuing Content

In this section on apparent boredom from not valuing content, I examine the theme, primarily from the questionnaire responses, which seemed to suggest that some apparent disaffection from the students stemmed from them seeing some content as too easy or otherwise not valuable. One lesson, Lesson 9, is examined to illustrate evidence from one activity which supports that some students did appear to find the content too easy. Following this, I query if in other lessons the content really was too easy in all instances of these responses and discuss that regardless, the perception seemed to interfere with engagement for some students.

### 'I learnt about that in like grade 4'

Some students' written responses seemed to show that there was subject matter they believed they already knew or was too easy for them. Both written sources of student responses, with 16 responses within the questionnaire and six instances within the exit slips, appeared to show students perceiving that they already knew the content, and this was reported as boring for them. Please refer to Table 7.4 to see both questionnaire and exit slip representative responses which seem to be expressing boredom due to knowing the content already or it being too easy. Boredom due to finding content too easy has been reported elsewhere including a large US study of secondary school students ($n$ = 81,499) (Yazzie-Mintz, 2007) and as reviewed by Vogel-Walcutt et al. (2012) across curriculum areas.

Table 7.4

*Apparent Boredom Due to Perceiving Knowing the Content Already or it Being Too Easy*

| Prompt | Illustrative Student Response | Reference |
|---|---|---|
| Questionnaire | | |
| I found learning about… | | |
| · different concepts of fractions | 'boring' because 'I learnt about that in like grade 4' | Qs-E-Anon |
| | 'boring' because 'I already knew it' | Qs-D-Anon |
| · difficulties people have with learning fractions | 'boring /repetitive' because 'we already know this' | Qs-G-Anon |
| | 'boring' because 'It was too easy' | Qs-I-Anon |
| Exit slip | | |
| Today I learnt about… | 'nothing, I already knew what to do' | Ex-L4-1/12-Anon |
| I was least engaged when… | 'when I was bored' because 'it was boring and not difficult' | Ex-L9-9/17-Isabella |

**Too easy**

I documented an instance in Lesson 9, a rotation of four activities, of students not engaging meaningfully in an activity because it had inadvertently become too easy. One student, Isabella, wrote in her exit slip for that lesson that she was least engaged 'when I was bored… 'cause it was boring and not difficult'. Before analysing the classroom video, I would have assumed that students did not engage in an activity because they did not know exactly what to do.

For Activity 3 in Lesson 9, students were asked to make a brief video showing fraction equivalence in two ways. Students were asked *not* to use the procedural adage, 'whatever you do to the top you do to the bottom' but rather show that multiplying a fraction by one, in the format of a number divided by itself, does not alter the original fraction value, then show that resultant equivalence with concrete manipulatives too. However, previous groups left their workings, so although a basic task for Year 8 students, for all but the first group, it appears to have become a rather pointlessly easy exercise. For example, the first and subsequent groups left the workings showing $\frac{2}{3} \times \frac{2}{2} = \frac{2 \times 2}{3 \times 2} = \frac{4}{6}$, so Isabella's group (the third rotation for that activity) only needed to pick up the two thirds and the four sixths plastic fraction pieces, place them next to each other, and then video the pieces and the prewritten equation.

I did not foresee that groups would use the workings of the first group. Furthermore, having the target audience of the student-created videos as younger students may have contributed to the seeming lack of cognitive engagement in the activity. Asking students to show, explain and video equivalence both through mathematical equations and hand-drawn representations of improper fractions may have been a better, more age-appropriate activity. Nonetheless, students made the videos, mostly in response to Serena's requests which seems to show the value of the relationship between the students and their teacher. Video evidence (please see Table 7.5) shows students still doing the activity, but yawning and slumping; chatting socially; tidying the plastic fractions pieces; or using the camera to video unrelated subjects, which seems to indicate low cognitive engagement and appears to be evidence that at least one activity was too easy for the students.

Table 7.5

*Events from Lesson 9, Activity 3, Rotation 3 from Classroom Video*

| Time | Person/s | Activity | Seconds |
|---|---|---|---|
| 15:01 | Serena | Explains to group what to do — show equivalent fractions for younger students in two ways, mathematically and with manipulatives. Checks for understanding | 70 |
| | Isabella<br>Maddison<br>Jenna<br>Cynthia | All appear to be listening. All looking at the materials on the table before them and at Serena. All nod slightly when looking at Serena | 70 |
| 16:15 | Cynthia | Yawns | |
| 16:37 | Maddison | Slumps her head on her arm on the table, then sits up and props her head up on her upturned left hand | 20 |
| 16:50 | Isabella<br>Maddison | Tidy fraction-wall pieces | 25 |
| 17:55 | Jenna<br>Cynthia | Jenna records two brief videos of Cynthia's face, zooming in and out rapidly, the second one finishing with a close-up of Cynthia poking out her tongue<br>(Student-produced videos 9 & 10) | 20 |
| 18:00 | Kate | Joins group | |
| 18:13 | Serena | Sees group have not started. Explains again what to do | 30 |
| 18:26 | Maddison | Yawns | |
| 18:31 | Cynthia | Yawns | |
| 18:34 | Isabella<br>Maddison | Work together to show equivalence between $\frac{2}{8}$ and $\frac{1}{4}$ | 10 |
| 18:50 | Jenna | Records two videos of Isabella and Maddison's creation<br>(Student-produced videos 11 & 12) | 20 |
| 18:54 | Maddison | Takes an already-written-on sheet and unhurriedly selects the appropriate recently tidied fraction-wall pieces to show $\frac{2}{3} \times \frac{2}{2} = \frac{2 \times 2}{3 \times 2} = \frac{4}{6}$ | 55 |
| 19:48 | Maddison | Pushes back on her wheeled chair to just outside of camera's frame. Appears to stretch out and rest | 60 |

**Too easy — or something else?**

Although evaluated as a major theme from this study with 10% of the responses from the questionnaire expressing boredom due to knowing the content already, I question whether this was indeed true in each case. Of the 15 students who completed the questionnaire, five seemed to find the topic of fractions concepts boring because they claimed they already knew it; three stated the topic was easy, but not necessarily boring; four seemed to find it boring or seemed not to care; and one seemed to find the topic 'great' because 'it actually showed me ways to work out different problems' (Qs-N-Anon). Please refer to Table 7.6 to see pertinent examples of students apparently finding some content too easy.

It is possible that the students did learn about the five different fractions concepts (part-whole, ratio, operator, quotient and measure) 'in like grade 4' (Qs-E-Anon), but unlikely because ratios and dividing and multiplying by fractions (using the operator concept of fractions) are both introduced in the Australian Curriculum in Year 7. Nonetheless, perhaps supporting the students' claims of prior knowledge, the pre-test results on different skills and knowledge on fractions concepts showed most students getting the first and easiest question on each fractions concept correct. However, most were not successful in the subsequent, harder questions, only one student could use fractions correctly in estimating and most could not explain their reasoning, the latter of which was most needed in creating the e-learning module. Furthermore, whether they knew the content or not, at either a conceptual or procedural level, it seems that some students *perceived* to know the content already, and that appeared to have a detrimental effect on their engagement levels.

What might be more salient is that the content was perhaps not made relevant for the students. I had assumed that the group creation of an e-learning module would provide the relevance for learning, but that assumption was apparently not supported as evidenced by the prevalent boredom theme in the responses of many students. So, even if the students actually did not already know about all five fractions concepts, but stated otherwise, it seems that many students did not value that content.

Referring to Table 7.6, it appears the importance of the personal relevance or irrelevance of the content can be seen when looking at the students' responses to the questionnaire prompt regarding learning about difficulties people often have with fractions.

It seems that only one student (Qs-M-Anon) expressed that learning about fractions misconceptions was interesting outside of being personally relevant for his or her own learning of fractions. The other students seemed to judge the value of the content based on whether it was perceived as needed for their own personal learning or not. So, here, two conditions seemed to have a negative effect on engagement: if the content was perceived as known already (including if that was true or a perception); and if the content was not deemed personally relevant and of value to the student.

Table 7.6

*Questionnaire responses to: 'I found learning about difficulties people have with learning fractions…'*

| Theme | Illustrative Student Responses | Reference |
|---|---|---|
| Already known, too easy or repetitive | 'boring' because 'I get that people all have their own problems and I was fine learning it, but we did it all the time.' | Qs-E-Anon |
| | 'boring /repetitive' because 'we already know this' | Qs-G-Anon |
| | 'boring' because 'It was too easy' | Qs-I-Anon |
| Irrelevant | 'Not very helpful' because 'I [it?] didn't reflect on my learning' | Qs-C-Anon |
| | 'not that fun' because 'they are different difficulties I have so I didn't understand how those things are difficult.' | Qs-K-Anon |
| | 'annoying' because 'I knew that people had trouble with them and I didn't, so it wasn't helping me learn' | Qs-O-Anon |
| Interesting | 'interesting' because 'I have similar struggles' | Qs-H-Anon |
| | 'interesting' because 'it shows what other people think' | Qs-M-Anon |
| | 'interesting' because 'it was what I found hard about fractions and how to solve the mistakes I so often made' | Qs-N-Anon |

### Just right challenge level and valuing

Boredom evoked from the content being too easy or being perceived as too easy could logically be addressed by knowing explicitly what each student understands, and then planning challenging activities to keep the learning in each student's zone of proximal development (e.g., Arcavi & Schoenfeld, 1992; Calder, 2015; Pirie & Kieren, 1992). (The zone of proximal development, see Vygotsky [1986], is the area between what the student knows and is yet to know, and where the student is challenged enough to engage and achieve without being under- or overwhelmed and where, with guidance, the student can make learning gains.) A researched method to successfully implement this is to use open-ended tasks with multiple solutions, multiple entry levels, and pre-prepared enabling prompts and more challenging extension prompts (e.g., Ingram et al., 2016; Russo & Hopkins, 2017; Sullivan, Mousley, et al., 2006).

The academic challenges in this study for the students were planned to be in understanding the problems people tend to have with fractions, and then in creating digital objects, quizzes and multiple-choice questions which explained those concepts to others. This was to give students an ostensible excuse for revisiting earlier concepts, an authentic reason for understanding the concepts deeply and the challenge, as perhaps experienced by teachers when creating lessons, in presenting and conveying ideas clearly. However, these assumptions appear to be largely unsupported, or perhaps thwarted, in that some students expressed that they knew the content already and appeared to be consequently disaffected.

The reasons for students not engaging when they appeared to perceive that they had already mastered the concepts may have stemmed in part to conditions peculiar to this study. In response to what seemed like students' disaffection for presenting an e-learning module on fractions to known peers for assessment and feedback, the target audience was changed to Year 5 or 6 students. I also thought this change might help students who had not yet mastered the concepts create digital learning objects about those concepts for younger students without loss of face. Rather than assuage what seemed to be some students' fear of exposure of incompetence to known peers or fear of demonstrating mastery that might undermine a peer friendship (if showing the finished e-learning module to peers at the same school), changing the target audience to Year 5s or 6s seemed to have created a different problem. It seemed to have helped evoke a sense that the content was too easy. In some cases, the activities did appear to be too easy, as when the first group left their workings out for other groups in Activity 3 of Lesson 9; in some cases, the content appeared to have been perceived as not personally relevant; perhaps in other cases students wanted to express that the content or the activity was too easy even if it was not.

The learning designed for this study was formulated in response to literature showing that many students do not understand fractions concepts (Clarke & Roche, 2009; Lamon, 2012; Zhang et al., 2015), may well be aware that they have gaps in their understanding in this area of mathematics (Wilkie & Sullivan, 2018) and that these concepts are vital for success in mathematics (Evans, 2017; Torbeyns et al., 2014) and in life beyond school (Capraro et al., 2014). Furthermore, pre-testing of these students showed that, in general, although they mostly performed well on fractions problems involving equivalence, ratio, part-whole, quotient and part-whole concepts, they did not perform well on the questions on measure, rates, operator or proportional thinking concepts (please see Appendix J for the pre-test questions and Appendix K for pre-test results). The students performed more poorly on harder questions. Also, the pre-test had questions asking students to explain their reasoning for the part-whole and operator concepts questions, and except for a small minority, they did not explain their working well. The latter may have indicated a surface or procedural understanding rather than a conceptual understanding (Chen, 2012; Hattie et al., 2017; Pitsolantis & Osana, 2013).

It was the classroom teacher's preference that the marked pre-tests were not returned to the students because it was her experience that those who did poorly on tests tended to over-react for an extended period (meaning she would be the one to deal with the fallout, not me). This made it difficult to show the students that they needed practice in explaining concepts to know the content deeply, improve in their understanding of fractions as operators and proportional reasoning and to be able to apply the knowledge to a variety of contexts (Perin, 2011). I showed them deidentified class results and went through those problems with which most people had trouble, but I sensed this had little impact. Perhaps it was not personally compelling. As found by Kapur (2014), vicarious failure is not as compelling as individual failure. Research by Black and Wiliam (2010) suggests that task-specific formative feedback has been linked with higher levels of engagement in learning, and by not giving the students feedback which related directly to their individual learning their engagement may have suffered.

Furthermore, I had included content in the study's lessons for which the students had performed well, but from the pre-test results showed they needed practice in explaining, and this may well have added to the feeling of being presented with work which was perceived as too easy by some students. Also, seemingly indicating low engagement, the post-test results revealed that mostly students had not improved in their understanding of fractions concepts except for Lissy and Siobhan, who created the fractions game together (please see Appendix F) and Lissy worked on the digital animation on fractions concepts. However, during normal class time and leading up to the post-test, the class studied ratios which possibly confounded the post-test results. Zach, Maddison, Kate and Isabella *actually scored lower in their post-test* compared to their pre-test (please refer to Appendix J for the pre-test — nearly identical to the post-test administered several months later — and to Appendix K for the students' results on the pre- and post-tests). The overall impression was that neither did the students value the group goal to create an e-learning module on fractions nor did they value many of the activities offered within the study.

Martin et al. (2012) found that in mathematics education with middle years students that valuing of mathematics was associated with continuing with mathematics studies and not valuing of mathematics was associated with disengagement from the subject. On a more micro level, expectancy value theory predicts that if a student does not value content or an activity, that student will not engage with that content or activity. Yazzie-Mintz (2007) found that for most secondary school students surveyed ($n$ = 81,499), boredom was due to uninteresting material (75%) or finding material irrelevant (39%). Reviewing the students' responses here, although seeing some video evidence of activities which were not challenging enough, I question whether in each instance those who seemed to express knowing the content already really did know the concepts deeply. However, when students wrote that they did not *value* the content, as well as it being hard to ascertain or dispute that by examining the video evidence, I intuitively did not question, but rather acknowledged that evaluation. It appears that some students seemingly not finding the content of value helps explain some of the rather widespread ostensible expression of disaffection found in the students' responses, but not valuing the content was not the only reason for apparent disaffection.

## 7.4 Apparent Pedagogical-based Boredom

In this section on apparent pedagogical-based boredom, I examine a main theme from the exit slips prompting when students were least engaged: passive pedagogy. I show that there seems to be degrees of disaffection for passive pedagogy. Video and other evidence is described from Lesson 4 which featured time where the students were expected to listen interspersed with other activities. I consider the perspectives from the classroom teacher and myself.

### Passive learning — seemed to be a major theme

Apart from the theme of boredom with no further explanation, the largest number of responses, 28%, to the exit slip prompt 'I was least engaged when…' was for too much passive listening or watching, especially with extended presenter talking (please refer back to Table 7.3; this theme was not evident in the questionnaire responses). I had presumed that because the lesson time-slot for which I was with the class was last period on a Friday, that the students would appreciate passive presentations interspersed with short activities or discussions rather than themselves having to write, concentrate for long periods and 'work hard'. I also assumed that the students would appreciate being treated like senior secondary and university students for whom I often used PowerPoint presentations interspersed with short interactive activities, and I told the Year 8 students it was my intention to treat them as young adults. However, it seems some students were *least* engaged when *not* working. This finding is expanded and discussed further in Chapter 8 when examining the responses of the students when engaged, so the presumption that it might not suit the class to work on a Friday afternoon appears to be unsupported. None of the evidence gathered suggested that the students liked the idea of or felt like they were being treated as young adults.

Passive learning themed responses, like (a) ‘You were talking’; (b) ‘we were watching the PowerPoint’; and (c) ‘there was explaining’, were reported from all self-reported engagement levels, from ‘not at all’ through to ‘all or nearly all the time’. So, for a range of students, it seems a more active, student-centred pedagogy might have been be more engaging. Please see Appendix G and note passive pedagogy themed responses are shaded grey.

To highlight the non-valuing of passive learning another way, of the 69 total exit slip responses, only one student wrote being *most* engaged with passive pedagogy, that is, when ‘listening and contributing’ (Ex-L5-15/17-Anon). Considering only this one student wrote of valuing listening and for many students the act of listening appeared to be disaffecting or perhaps least engaging, the theme of passive learning activities seems to warrant further investigation as a potential disaffecting factor in this study.

**Study of a lesson**

To give context to the overall data on passive pedagogies, I wanted to examine a lesson where presentations were featured and which had good video evidence to corroborate (or contrast) and triangulate any findings, so Lesson 4 was selected.

The aim of Lesson 4 was to explore different ways of representing less familiar part-whole area and region fractions and to open discussion on how to convert problem solving activities in the classroom to activities for the future online users of the e-learning module. Part of the theoretical basis for the lesson was a response to the assertion by Lamon (2012) that students tend to have insufficient exposure to multiple region and area representations of fractions and are overexposed to circles divided into segment fractions (often depicted as pizzas, cakes or pies). As shown in Table

7.7, the session was run with me talking and referring to a PowerPoint presentation and stopping throughout to ask students to complete a brief think-pair-share activity or to answer a question.

As with the pooled exit slip data (please refer to Appendix G), the exit slip responses for Lesson 4 were sorted in Excel first by self-reported engagement level rating, from 1 (not at all) to 5 (all or nearly all of the time), then self-reported learning value rating, from 1 (low) to 5 (high), and categorised and colour-coded according to theme (please see legend of Table 7.8). Referring to Table 7.8, the colour-coding allows patterns to be seen without statistical analysis, deemed appropriate for such a small sample of mixed qualitative and quantitative data. For this lesson, the engagement level had a mean of 1.9 which shows that, on average, the group of students expressed that they were, at best, engaged for a little of the lesson.

Table 7.7

*Activities of Lesson 4*

| Time mark | Activity | Question posed |
|---|---|---|
| 01:40 | Drawing in books<br>Think-pair-share<br>Students presenting solutions on board | ‘Can you divide an equilateral triangle into quarters?’ |
| 06:00 | Question<br>Think-pair-share | ‘What is different to the way we can solve problems in the classroom compared to how our e-learning module users will be solving problems?’ |
| 13:30 | Drawing in books | ‘Have a go at dividing a shape into fractions of equal area but make the fraction pieces different shapes. You can choose any shape and any fraction’ |
| 28:06 | Website displayed on classroom TV screen | ‘Let’s have look at some digital learning objects in Scootle [an online repository of digital learning objects linked to the Australian Curriculum and sortable by subject, year level and topic]; are they age appropriate or too kiddie?’ |

*Note*. Time marks from (Video 12 May 2017)

Table 7.8

*Categorised, Sorted Exit Slip Responses from Lesson 4 — Presentation and Short Activities on Fraction Area Concepts*

| Student | Engaged SR | I was most engaged when I was… | I was least engaged when… | Learning SR | Today I learnt about | It helped me learn when… | It interfered with learning when… |
|---|---|---|---|---|---|---|---|
| 1 | 1 | working in our books drawing a shape | it was boring | 1 | nothing, I already knew what to do | nothing | You kept on talking and it was boring |
| 2 | 1 | writing in books | it was boring | 3 | stuff about fractions | we did stuff in books | |
| 3 | 1 | not here | here | 5 | stuff | thing | not shore |
| 4 | 1 | messing around | watching/ listening | 5 | I knew it all | I already knew all of it | I wasn't learning |
| 5 (Sally) | 1 | talking to friends, messing around | looking at | | | | |
| 6 | 2 | I don't know | most of the time | 1 | not sure | not sure | not sure |
| 7 | 2 | we were trying out quizzes and working in groups | most other things | 3 | dividing shapes into other shapes | | |
| 8 | 2 | working with group | Everything else | 3 | The certain things we will do | Nothing helped | Everything |
| 9 | 3 | Doing the work in the book | The talking went on | | | | |
| 10 | 3 | working in our books | it was boring | 1 | dividing fractions | I already knew it | I got distracted |
| 11 (Zach) | 3 | doing the activities | there was explaining | 4 | what group I'm in | When it came on the board | People talked |
| 12 | 3 | in front of the class | people were talking | 4 | fractions | I was in front of the class | |

Key:

| Engaged in learning | Others help learning | Neutral | Distracted | Disaffected/bored | Disengaged | Engaged socially | Learning too passive | Too easy / Already known |
|---|---|---|---|---|---|---|---|---|

*Note.* Responses sorted by self-reported (SR) engagement and learning ratings (1-Low to 5-High).

Five responses from the exit slip data from Lesson 4 indicated that those students were least engaged, or it interfered with their learning, when they were expected to passively listen to the presenter or watch the presentation. Three of these five students rated no engagement with the lesson. Two students, responses Ex-L4-4/12-Anon and Ex-L4-5/12-Anon, seemingly rated their learning level incorrectly at 5, perhaps meaning for them they knew everything already rather than giving a rating of their learning attained during the lesson. Two students, Zach (Ex-L4-11/12-Zach) and Student 9 (Ex-L4-9/12-Anon), marked that they were engaged about half of the time and were most engaged when ‘doing the activities’ and ‘Doing the work in the book’.

Zach’s response seems to show that the lesson was not completely disengaging for him, but rather that the stated disaffection for the lesson was confined to the part of the lesson when ‘there was explaining’. This seems to tie in with the research finding that teacher-centred pedagogies can be less engaging for students and student-centred pedagogies are more engaging (e.g., Calder, 2015).

One of the responses was rather direct: ‘You kept on talking and it was boring’ (Student 1 from Table 7.8; Ex-L4-1/12-Anon). This was written in response to the exit slip prompt ‘It interfered with my learning today when…’. Although rating no engagement with the lesson, this student did state he/she was most engaged when ‘working in our books drawing a shape’. It seems that for this student, the level of engagement was weak, and the level of disaffection strongly overshadowed any engagement. Two other students in Lesson 4, who also rated the lesson with no engagement, indicated that passive listening or watching was disaffecting. In response to the prompt ‘I was least engaged when…’, Sally wrote ‘looking at [unfinished]’ (Ex-L4-5/12-Sally) and the other student wrote ‘watching/listening’ (Student 5 from Table 7.8; Ex-L4-4/12-Anon). For these students, it appears one of the reasons they rated their engagement in the lesson poorly was due to passive presentation time.

### The teachers' perspectives on listening

It appears students were disaffected by passive pedagogy as seen in the exit slip responses in general and in the example of Lesson 4, and this was noticed by and had an effect on the researcher/presenter (me). I reflected the following in my journal:

> It's not all going exactly as I expected. I'm getting feedback from the students which signifies that they are least engaged when I'm speaking. However, both Serena and I would say that they are engaged when I am explaining concepts most of the time. On the other hand, I also have a sense when I'm losing an audience — then improvise and shorten or truncate what I'm going to say. Considering I have had to do this each lesson with this group, this means I *am* talking too much. So, I will have to rethink how to teach the concepts. (Researcher/presenter reflection; Saturday 20 May 2017; 12:42 pm)

This reflection seems to acknowledge that the students were somewhat engaged in the lessons, but also that their attention waned as the presentations continued. This appears to align with Serena's statement: 'They like to listen to you when you explain. But if the task lasts for a long time, I don't know if they will concentrate' (Serena; Teacher interview; 26th May 2017; 0:41 to 0:54) and furthermore, 'They can't listen or they can't concentrate for more than few minutes' (Serena; Teacher interview; 12th May 2017; 20:05). Both my and Serena's perspectives seem to acknowledge that the students would listen if the presentation was brief. Perhaps the students' disaffection was particularly for prolonged passive pedagogies?

From Serena's last-mentioned quote, it seems that the students' apparent inability to learn and engage well with passive pedagogies, particularly if prolonged, was not restricted to this study, but was rather more general. Serena also explained that even if there was something to watch, like a PowerPoint presentation, that for her, often lower secondary students' ability to concentrate was low, but this improved by Years 11 and 12 when students had matured and were more focussed on their studies.

**Fun**

There was some evidence from the study to support that some students appeared to be somewhat focused on fun, games and entertainment, and had difficulty listening. In the questionnaire responses, there were 13 instances of the use of the word fun and only four of these were used in a positive sense, aspiration for or appraisal of the activities. Qs-I-Anon wrote that learning about benchmarking and visualising of fractions was not engaging and ‘I'd rather do something fun like go-karting’. Qs-J-Anon used the term ‘not amusing’ four times, and in response to the questionnaire, appeared to link lack of entertainment with not concentrating or perhaps vice versa. For example, in response to learning about fractions concepts, Qs-J-Anon wrote it was ‘not amusing’ because ‘I didn't really listen and it was boring’.

Drawing on the field of developmental psychology, Murray-Close (2013) reviews that, from one theoretical perspective, some individuals have lower levels of sympathetic nervous system arousal and these ‘underaroused individuals require heightened positive input to experience typical levels of reward’ (p. 239). That is, some individuals seek external stimulus, like fun, drama and excitement, to compensate for lower internal stimulation. There is no evidence to suggest that this mechanism was operating in this study, but nonetheless it is interesting to consider. It seems that the classroom activities presented in this study might have been stimulating enough for most students at least some of the time, but some students seemed to experience or report most or perhaps all the activities as under-stimulating, that is, as not engaging, not fun or simply boring. Due to the anonymity of the written data, it is not possible to know if the same students each lesson reported no engagement with the lesson, but the handwriting on the exit slips seemed to suggest this.

**Video evidence on passive learning**

In one way, the video evidence seems to corroborate the written exit slip responses from the students that many were least engaged when expected to listen. For example, at one point in Lesson 4 when I was explaining the difference between region and area models of fractions, t =10:05, three of the nine students in this view (Nathan, Logan and Hunter; 12 in total were present that day) had their heads in the hands, only four appeared to be looking at the presentation (Logan, Hunter, Jacob and Jenna), two appeared to be chatting (Isabella and Cynthia) and the rest were looking elsewhere. Postures were slumped. Noting that parental consent was not gained for sharing images of students in printed media (therefore cannot be reproduced here in this thesis) and conferring with senior colleagues to draw inferences, this appears to show that the students were not particularly engaged when the presenter (me) was talking at that moment of the lesson. From regarding both the exit slip responses and the video evidence, the students appeared to be bored due to too much presenter talking. Also underscoring that the passive pedagogy was problematic, , the corroborated video evidence showed that the students' engagement seemed to pick up readily when asked to perform an activity.

**Passive learning findings and the literature**

In reference to definitions in the literature, Gettinger and Walter (2012, p. 653) stated that student engagement is the 'actual involvement or participation in learning', and similarly, Liem and Martin (2012, p. 3) and have defined engagement as the *behaviours* aligned with the 'energy and drive' to learn. Similarly, the working definition of engagement for this study, 'is behaviour and mental processing directed towards achieving learning goals and is associated with enjoyment or interest'. The findings here show that the students were often least engaged when the presenter was talking or explaining and when the students were required to take passive roles in listening and watching. These findings align somewhat with all three definitions in that the students were not required to be behaviourally engaged in the learning when passively listening and may have felt they were not *actively* learning, and as such, reported that they were not engaged or the least engaged when listening. That is, as well as probably reducing presenter talking time to increase students' engagement, another part of engagement, mental processing or cognitive engagement, was not sufficiently recognised, emphasised or strategically valued by either the presenter or the students. This seems to suggest that the students felt more engaged when active and needed help to recognise, value and enact active listening.

Hintz and Tyson (2015) reported that listening, as well as being an under-studied but important part of mathematics discourse, is effortful and multifaceted. They stated that the aim of students listening is to make sense of, interpret and evaluate what is being presented. It appears active, complex listening needs to be taught (e.g., Hoong et al., 2014), but first understood by the teacher. Davis (1997) argued that good mathematics discourse starts with the teacher listening to the students, and this is not a feature of passive pedagogies.

Of note is that Frings (2011) found with military cadets that fatigue-induced cognitive impairments were diminished when subjects worked on mathematics problems in groups. Perhaps particularly during last period on Friday afternoons in a mathematics classes when the students seemed tired, passive pedagogies were less engaging, and that group work, active discourse or student-centred investigations, each of which were utilised in several stages in Lesson 4, could have been emphasised and passive pedagogies diminished further to help with increasing students' engagement. It also appears that strategic teaching of the value and skills of active listening may have aided engagement.

Martin et al. (2012) found that disengagement was negatively correlated with enjoyment, valuing and self-efficacy in early adolescent mathematics education. It seems that passive learning activities here were not engaging for the students (only one student wrote being most engaged with 'Listening and contributing'; Ex-L5-15/17-Anon). Listening as an activity appears not to have been strongly valued (valuing has been linked to making the relevance explicit, see Stroet, Opdenakker, and Minnaert, 2013) and may have not given students enough opportunity to demonstrate competence. These possibilities seem to align with Martin and colleagues' findings.

Adding to the complexity is the possibility that some students were stating they were least engaged, particularly when I was talking, for social reasons or perhaps as a power play. For example, the student who wrote 'You kept on talking and it was boring' (Ex-L4-1/12-Anon) might have just been expressing frustration or there may have been an edge to it; perhaps this student was expressing anti-establishment disaffection in a manner for which there would be no repercussions and possibly acting out of lack of perceived control or some other psychosocial factor? However, there is not enough evidence to draw such conclusions from this one response. On the other hand, as discussed below, there seems to be some evidence in the data to suggest some students wanted to maintain a 'boring' narrative and perhaps some students were prone to experiencing everything as boring.

**Video evidence — was it that boring?**

Further examination of the video evidence seems to challenge some students' appraisals of no engagement. Referring to back to Table 7.8, five students of the 12 students self-rated that they were not at all engaged in Lesson 4, but the video evidence (Video; Lesson 4; 12th May 2017) suggests mostly the 12 students seemed to be engaged, especially when working out solutions to problems posed and watching classmates present their solutions. For example, when trying to divide an equilateral triangle in quarters, video evidence shows each student in their groups leaning towards the centre of the group and they appear to be watching the person sharing his or her solution/s with the group. In one group, Jacob and Nathan can be seen twisting in their seats and turning around to join Logan, Hunter and Zach. All five boys' bodies are angled toward the centre of the group where Hunter appears to have the pen (his hands are obscured from the camera by Jacob's body) and is working on a solution to which the others are looking at and contributing. Zach is smiling (Video; Lesson 4; 12th May 2017; 2:36).

As another example, at t = 3:53 of the video, the class was watching Isabella at the board show how she divided a triangle into quarters. Apart from Zach who was still working on his problem, all others' gaze appeared to be on the board or watching Isabella and their bodies are angled towards the board. This appeared to be an indication of engagement.

As a further example, when Hunter showed the class his idea for dividing an equilateral triangle into quarters, class members again have their bodies angled toward the front of the room and appear to be looking at the presenter. At this point (Video; Lesson 4; 12th May 2017; 4:29), Isabella lightly says, ‘Oh, yeah’ with an inflection at the end as seemingly acknowledging another way of solving the problem for which she had just presented.

Unfortunately, the camera did not pick up each member of the classroom but did mostly capture 11 of the 12 students present. Nicole was mostly sitting off screen. Two students, Nicole and Maddison, left the class for a toilet break for nearly five minutes (3:00 to 7:54). Near the end of the lesson when looking as a class at digital learning objects (DLO) in Scootle, Nicole interjected several times insisting that we try to divide a shape into 137ths when it was explained (twice) that the DLO could only handle divisions up to 12ths. Nicole had to be cautioned not to persist. So perhaps Nicole was not engaged for the lesson, but this does not explain why there were five students who self-rated their engagement as ‘not at all’ for the lesson when the video evidence seemed counter to this rating.

There seems to be seven (non-exhaustive) possible explanations for the discrepancy between some students’ self-rating of no engagement for the lesson and the video evidence suggesting at least moderate engagement. Firstly, it could be that the students were tired last period on a Friday, as ostensibly evidenced by their slumped postures and occasional yawns, and they conflated some of their tiredness with low engagement. Vogel-Walcutt et al. (2012) reviewed that often students have difficulty separating boredom from other experiences and will default to stating something is boring when in fact they are tired, or even frustrated. Secondly, perhaps some students rated engagement according to or comparing with what they would rather be doing. For example, compared to ‘go-karting’ (Qs-I-Anon) it was not as engaging to learn about how and why to include a variety of shapes and fractional divisions in the e-learning module. Thirdly, it could be that the end of the lesson, which did include more explaining (on the difference between fractional areas and regions), was dull for the students and overshadowed any engagement experienced earlier.

Fourthly, it could be that students were making a social statement intended to show a lack of cooperation with an intruder into their space and that a positive pedagogical relationship (Attard, 2014) had not been established. For example, one student wrote rather directly, ‘You kept on talking and it was boring' (Ex-L4-1/12-Anon). Perhaps this is similar to the experience of casual relief (substitute) teachers who, as well as often feeling outside of the school's community of practice (Nicholas & Wells, 2017), are often subject to worse behaviour from the students (Nidds & McGerald, 1994). If the latter, then presumedly as the weeks progressed, the students' engagement ratings would increase as they became comfortable with me in their presence. The subsequent average engagement level ratings were higher in the ensuing lessons, but consistently throughout the study, some exit slips were still marked with no engagement.

The final proposed three possible reasons for students seeming to rate the lesson lower in engagement than what was apparent in video evidence (as assessed by me) are discussed in more detail in the next section in which I explore what seemed to be rather persistently-expressed disaffection from some students. So, fifthly, it could be that some students were 'acting out' due to psychological needs consistently not being met. Sixthly, possibly some students were maintaining a 'boring' narrative that was perhaps intended to engender a sense of solidarity amongst the students and mixed with perhaps the enjoyment of being a bit rude with no disciplinary repercussions. Lastly, perhaps some students experienced everything as boring (boredom proneness or trait boredom), meaning it would not matter how engaged their peers were and how engaged they appeared to be in the video evidence, if boredom prone, such students would not experience the activities of this study, and presumably others in their school life, as engaging.

### 7.5 Persistently Expressed Boredom

For much of the discussion thus far, the students' own words and actions have been thematically categorised and discussed to hopefully account for much of the boredom and other disaffection the students expressed. However, most of the boredom expressed in the exit slips and questionnaire could not be thematically assigned beyond 'boredom' because no reasons for it were given. It seems plausible that some of that unassigned boredom would be due to the themes already discussed, including situational boredom from logging in and other computer-related problems, passive pedagogies and students not valuing the content. However, it appears some expressed boredom is not attributable to the extant themes in that it appeared consistently expressed regardless of the situation, activities or pedagogy.

Irrespective of the different activities offered, each week there were some students who gave the lessons the lowest rating for engagement in their exit slips. Furthermore, whereas most students responded with a mixture of engagement and disaffection in the questionnaire, three anonymous students (denoted as Qs-A-Anon, Qs-F-Anon and Qs-G-Anon; please see Appendix H) reported disaffection for every activity surveyed in the questionnaire. Tellingly, these students responded with disaffection even to the aspirational prompts. For example, in response to ‘The digital learning objects that I would find effective for my own learning of fractions would…’, they wrote: ‘not exist’ (Qs-A-Anon); ‘boring AF’ (Qs-F-Anon), and ‘not do much cause their boring’ (Qs-G-Anon). It is not known if it was the same students who reported strong disaffection each week in the exit slips, but the handwriting of the responses across the cohort suggest that it was the same students who were consistently expressing disaffection.

**Acting out?**

Perhaps some students were ‘acting out’ by rating the lessons poorly for engagement because psychological needs were not being met? Skinner and Pitzer (2012) present a model of student engagement based on self-determination theory, Self-System Model of Motivational Development (Connell & Wellborn, 1991; Deci & Ryan, 2000), and explain that teachers can shape students’ engagement by giving students options in their learning, making the learning relevant (related to autonomy, if the value and relevance of an activity or learning is made explicit it supports students willingly choosing that activity), fostering a sense of belonging with warm teacher-student relationships (Attard, 2014) and providing structure that helps students build competence. Skinner and Pitzer explain that students tend to act out or withdraw if their needs for autonomy, relatedness and competence are not met.

In Lesson 11, Hunter's behaviour could be interpreted as acting out or perhaps experiencing reactant boredom (Goetz et al., 2014) and Nathan's was perhaps a form of withdrawal, possibly apathetic boredom. In this lesson, I was trialling a new (for me) approach in trying to help students make cognitive connections between different fractions concepts by asking students to make videos or stop-motion animations showing inverse relations with the following: run and gradient; time and speed; and the number of partitions and their size. Hunter's group was asked to video the trial of a new gradient device which I had devised to help students see the connection between gradients and fractions and that the greater the denominator the smaller the fraction, that is, if the rise is kept the same and the run increased that the gradient would decrease.

Hunter stood in front of the classroom camera to block its view (and called to his friends to watch him stand in its way), instigated a game of throw and catch, wandered around the room and evaded and perhaps even undermined the production of his group's video. Nathan spent most of the lesson, apparently in his own world, practising what looked like kicking tricks and dance moves.

Perhaps the trials were an unwelcome, constantly changing disruption which failed to establish the structure (see Stroet., Opdenakker, & Minnaert, 2013) and engaging repertoires (Attard, 2014) needed to build competence that I had seen were well formed in Serena's classroom before the study started. However, after the lesson Serena explained that, 'The boys like that, they need to be… I think they need to be sitting down at the table, just saying, 'Don't move; just do the work'' (Teacher interview; 21 July 2017; t = 3:00). This seems to suggest that 'boys like that' will behave in this way even for their regular classroom teacher if given the leeway to move around.

**Boredom proneness?**

Another possibility is that some students in the class suffered from trait boredom which refers to an individual's 'propensity to experience boredom' (Vogel-Walcutt et al., 2012, p. 90) or boredom proneness (Farmer & Sundberg, 1986) meaning that almost regardless of what was presented, affected students would experience it as boring. Farmer and Sundberg's 28-item Boredom Proneness Scale includes items on experiencing a lack of concentration and finding tasks meaningless, dull and under-stimulating, for example: ‘I feel that I am working below my abilities most of the time’; ‘Unless I am doing something exciting, even dangerous, I feel half-dead and dull’ and ‘Many of the things I have to do are repetitive and monotonous’. Farmer and Sundberg also found that undergraduate students who scored highly on their Boredom Proneness Scale were somewhat, but not significantly, more likely ($r = .23$; $p < .09$) to rate more topics in a lecture as boring than their classmates.

Throughout this current study, some of the students’ (anonymous) responses seemed to fit this pattern of boredom proneness. For example, in the questionnaire, one student wrote that every activity was boring, pointless or useless: ‘I found working in groups on different problems involving fractions…’ ‘boring and pointless’ because ‘it was unengaging’ (Qs-A-Anon). Also, on an exit slip in Lesson 9, another student (or perhaps the same) responded that ‘Every part’ was least engaging because ‘This is boring’ (Ex-L9-2/17-Anon).

The video footage perhaps shows evidence of two students who might have been boredom prone. Throughout the study, video footage shows Hunter apparently answering questions happily sometimes, and then perhaps when the focus was not on him, he would seem agitated and look for more stimulation or appear sullen. For example, for Lesson 7 with group work, perhaps showing preplanning for non-engagement, instead of helping his group with their fractions problem, Hunter took out a pair of pliers and wire and fashioned the wire into fishhooks. In Lesson 9 with the rotation of four activities, he sat in one chair, rocking slightly, and refused to join his group. In Lesson 11, as described earlier, Hunter roamed around the classroom, bounced the ping pong ball off the gradient device and stood in front of the classroom video camera blocking its view of the classroom and called to his friends to watch him do so. These incidents seem to build a plausible picture of boredom proneness for Hunter.

Nathan’s disaffection seemed different. He appeared quite happy to drift in and out of paying attention. Sometimes he sat on the floor, and if sitting on a chair, often his gaze would be directed elsewhere or at times he would lower his head down to the table, then pitch his body and head backwards so his hair would flick back in an arc. If the class set-up allowed more freedom, like with Lesson 11, he appeared to spend the time mainly practising various manoeuvres, what looked like dancing mixed with martial arts. If asked to engage, he would do so momentarily, and then drift back to his own activities. On one occasion in Lesson 9 it looks like he took an object from Jacob and this caused a disturbance. However, mostly it appeared that Nathan's behaviour was not directed towards attention-seeking in that, unlike Hunter, he did not ask his friends to watch him or attempt to inveigle his friends to join in. He just seemed to be tuned out to classroom activities and tuned in to his own personal narrative. (Serena told me she had spoken to Nathan's parents on several occasions to express her concerns and try to work out some strategies to help him engage in his studies.) The descriptions of the boys' behaviour seem to indicate both might be boredom-prone, and one was acting out and attention- and stimulus-seeking and the other had withdrawn.

From what I had seen of Serena's classes before the study started, they were structured, orderly and calm. Students were seated in rows facing the front. Neither Hunter nor Nathan got up and wandered around. Everyone appeared to be doing the work set, although Nathan, Hunter and others sometimes appeared to need encouragement to get started. Students would raise their hands for assistance or for Serena to encourage and congratulate them if they had achieved an exercise and were ready for the next challenge. In comparison to the behaviours videoed in Lesson 11, it seems not being seated and not having written work to achieve afforded Hunter and Nathan leeway to not engage in their learning.

## 7.6 Discussing Findings through the Theoretical Framework for this Study

As noted in previous chapters, and depicted in Figure 7.2, the theoretical framework of this study draws on expectancy value theory, EVT (Eccles et al., 1983; Wigfield & Eccles, 2000), self-determination theory, SDT (Deci & Ryan, 2000), and the control value theory of achievement emotions, CVTAE (Pekrun, 2006). In this chapter, findings which suggest expressions of disaffection have been examined. The relevant sections for the discussion in this chapter are highlighted in yellow in Figure 7.2.

According to the review by Vogel-Walcutt et al. (2012), boredom is ‘an unpleasant (subjective), low-arousal (objective) experience’ (p.89) and if a student does not value a topic or an activity (low-arousal), and is forced to do it, then it becomes boring (unpleasant). This means that in this study, when students presumably felt and apparently expressed genuine boredom (that is, did not express boredom for social reasons or conflate it with another feeling, like tiredness) they did not value the topic or activity and some external factor was holding them to continue involvement with it despite not being intrinsically motivated to continue. Data was not gathered to speculate on what extrinsic factor was holding the students to continue involvement, but the results revealed two main sources of boredom: (a) not valuing the content or activities, including perceiving the content as too easy or already known; and (b) passive pedagogy.

Expectancy value theory holds that individuals choose to engage or not in a learning task depending on whether they value it or not, whether they perceive they can do it or not, and on the costs and benefits of engaging. In this study, it appeared that some students evaluated some topics and content as valueless and did not seem to engage. This is depicted by the vertical drop from the box ‘Goal valued or not, EVT’ to disengagement. For example, in answer to the questionnaire prompt about visualising and benchmarking with fractions, one student wrote it was ‘useless and pointless’ because ‘it didn’t help in any way’ (Qs-A-Anon). Other students appeared to attempt to engage but became frustrated or bored as the activity ensued. This is depicted by a yellow arrow leading down from engagement in Figure 7.2. For example, in answer to the questionnaire prompt about difficulties people can have with learning about fractions, one student wrote that it was ‘boring’ because ‘I get that people all have their own problems and I was fine learning it but we did it all the time’ (Qs-E-Anon).

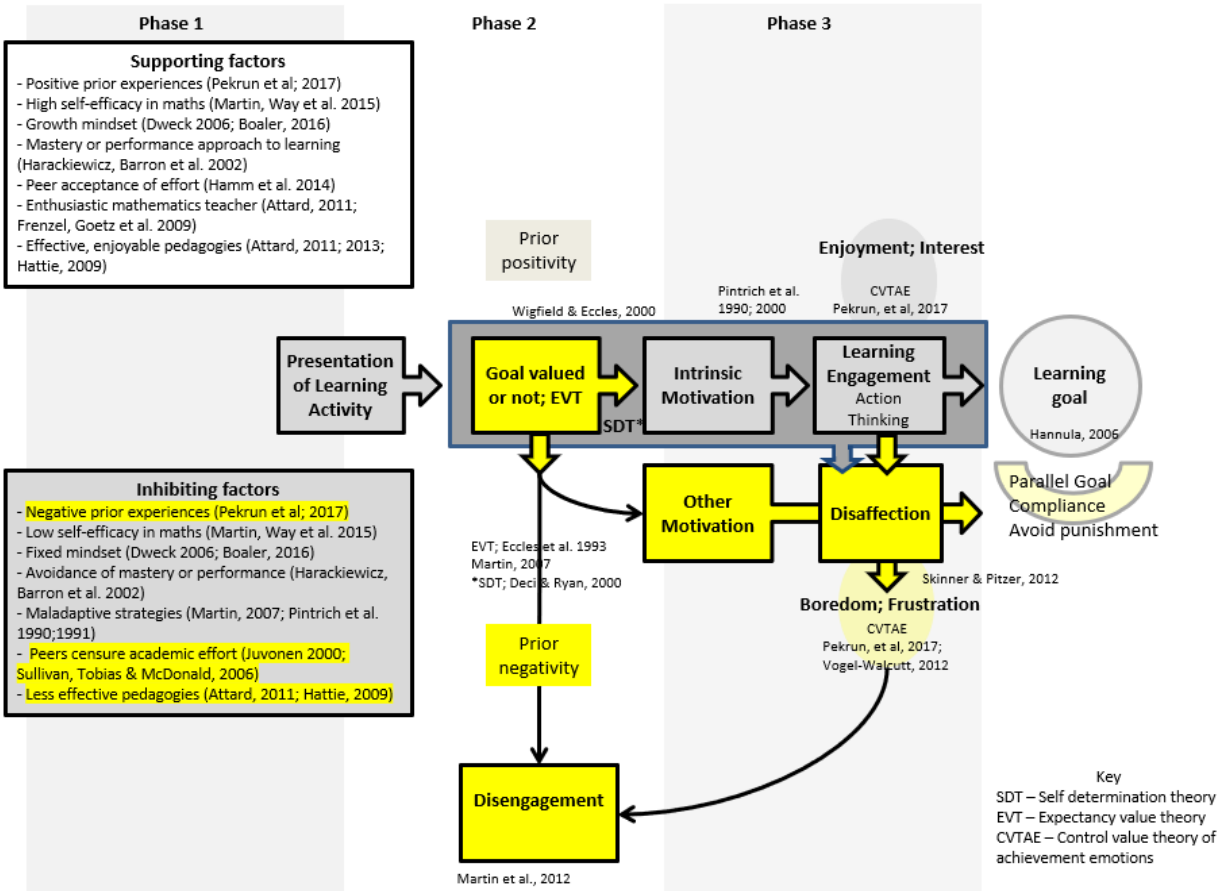



*Figure 7.2.* Theoretical framework of EVT and SDT mediated pathways to disaffection and disengagement, and inhibiting factors pertinent to this study

Another avenue to disaffection would appear to be not valuing a topic or activity but having a parallel goal, like compliance or wanting to avoid displeasing a respected teacher while struggling with the boredom or frustration of being detained in a trajectory which they do not value. For example, in answer to the same questionnaire prompt about difficulties people can have when learning about fractions, one student wrote, ‘I knew how to do them already and it wasn't focusing on my problems. It was for years below us and it was not amusing’ (Qs-J-Anon). This response seems to indicate that the student listened enough to know what the topic was about but was frustrated that his or her individual needs were not being met and bored by the content perceived to be too juvenile.

Self-determination theory holds that individuals have three innate psychological needs, competency, autonomy and relatedness. Stroet et al. (2013) reviewed that all three needs must be supported and met for students to maintain intrinsic motivation in learning. A suggested pathway for this loss of intrinsic motivation is depicted by the small dark grey arrow leading from the SDT background to disaffection. In this study, many students reported being least engaged and bored with prolonged presenter speaking. This would seem to impinge on the students' need for autonomy in that they are not offered a choice of responses when expected to listen and watch passively.

According to SDT, attaining competence is a basic human need and therefore is required to be satisfied for students to best engage in learning. Passive forms of learning perhaps do not give students an opportunity to demonstrate competence. Supported by the data, a passive form of learning — listening to a presentation (despite being intermingled with questions and brief active learning tasks) — was recorded as disaffecting or the least engaging for many students. As might be expected in regard to psychological needs of which students may not be consciously aware when learning (Bjork et al., 2013; Deci & Ryan, 2000), it is of note that students did not specifically state that presentations were boring or least engaging due to not feeling competent.

One student might have shown that he/she felt engaged in Lesson 4 when *demonstrating* knowledge. Within Lesson 4, willing students were asked to come to the board and demonstrate their thinking. Student 12 in that lesson (Ex-L4-12/12-Anon; please refer back to Table 7.7) stated that he/she was most engaged (SR for engagement of 3, the maximum rating for that lesson) when 'in front of the class'. There is not enough evidence to conclude that this student's statement shows that demonstrating competence was engaging, but it is plausible. It is also plausible that for this student, presenting in front of the class was more about being recognised, and therefore was a socially driven act.

Self-determination theory also holds that humans have an innate need for relatedness, and passive forms of learning or disseminating information do not readily allow for interaction. Evidence to support this was found in this study, but not by students directly stating that their need for interaction was not met in lectures, rather that they were more engaged in interactive activities involving group work. For example, in answer to the questionnaire prompt ‘I found working in groups on different problems involving fractions…’, one student wrote ‘not bad’ because ‘I got to be with my friends and I really like working with them and we all get along and I love them’ (Qs-K-Anon). Another wrote that group work was ‘enjoyable’ because ‘I was with my friend and we could all take part and do something’(Qs-O-Anon). Also, in their self-rating of engagement (1 = ‘not at all’ to 5 = ‘all or nearly all of the time’), students rated Lesson 4, in which a presentation took up much of the lesson, lower on average for engagement (mean = 1.9, $n = 12$) than lessons which involved more group work (Lesson 5, fractions group work, mean = 2.8, $n = 17$; Lesson 7, fractions group work, mean = 2.7, $n = 14$; Lesson 9, rotation in groups of four activities, mean = 2.8, $n = 17$; and Lesson 11, three inverse proportion activities and plenary, mean = 3.0, $n = 9$).

When viewed in the light of EVT, which holds that an individual’s self-motivated engagement in an activity is determined by the costs and benefits that they associate with that task and their prediction of success (Eccles et al., 1983), it seems the value of listening to a speaker would depend on the content. Using this theory, a student would question the benefit in attending to a presentation. If the benefit, for example, in learning about representing fractions in more ways than just pizza-like circles was understood as instrumental in selecting and creating DLOs for an e-learning module on fractions, and students valued the goal of creating an e-learning module or the student was simply interested in the topic, then EVT would predict that students would be engaged with that content. However, if the benefit was not apparent or, if apparent but not desired, then the students would be less likely to engage in the content. However, the data collected from the exit slips appears to show widespread disaffection for perceived prolonged speaker talking, or the activity of listening, not on the specific content (the questionnaire data showed responses to specific topics), so explaining the apparent disaffection for passive learning activities in terms of the content does not seem to be supported in the exit slip data set.

If there was a perceived cost in attending to the presentation, for example, the perceived social cost of appearing interested in what peers thought was not interesting (Clasen & Brown, 1985; Hamm et al., 2014), then EVT would predict that students would have a further reason for not engaging with the presentations. However, there was no direct evidence that the latter contributed to the findings regarding perceived prolonged presenter speaking.

As well as valuing the activity and evaluating the likelihood of success, Pintrich and De Groot (1990) describe a third motivational component for students when considering engagement in a task: their emotional reaction to and interest in the task. The emotional reactions to perceived prolonged presenter speaking seemed to be boredom and annoyance. The control value theory of achievement emotions holds that students engage in learning depending on the value they see in the learning and in the amount of control they perceive they have. Considering students did not seem to express interest and enjoyment (Pekrun, Goetz, Frenzel, Barchfeld, & Perry, 2011) regarding passive learning activities, but rather the opposite, it would seem that low valuing of the activity of listening and possibly perceiving a low degree of control might help explain why the students tended to rate the passive learning activities with low engagement value.

With persistently expressed boredom, the students' possible motivations were deducted from the evidence rather than directly stated by the students themselves, so it involves more conjecture to suggest a pathway to disaffection or disengagement. Nonetheless, if students were expressing boredom for social reasons, then they may not actually be bored so this would not be represented on the graphic representation of the theoretical framework. If students were boredom prone, that could perhaps be added to the inhibiting factors influencing engagement. Also, drawing on EVT, perhaps such students might not value anything but the most exciting activities and when presented with a 'normal' learning activity their involvement might drop directly to disengagement. However, it is beyond the remit of this study to project a pathway for disaffection experienced and expressed by boredom prone individuals.

## 7.7 Concluding this Chapter

Boredom seemed to be a major theme in this study as it featured strongly in both the questionnaire and exit slip responses from the students. Several sub-themes were noted from the questionnaire, the first one being boredom without a specific explanation as to its cause and the others were mostly encapsulated by the theme of students not valuing the content, including finding it too easy or already known. There were two main themes found from the exit slip responses to the prompt ‘I was least engaged when…’: boredom (again, without explanation) and passive learning pedagogy. A third undercurrent, perhaps of boredom proneness or a narrative of ‘boredom’, seemed to contribute to the expression of disaffection. This was harder to identify because did not come directly from the students’ written or spoken responses but rather was interpreted by me when there appeared to be a discrepancy between some students’ reported level of engagement and that seen in the video evidence and from direct video evidence.

So, it seems the following two factors may have accounted for much of the expressed boredom in this study: (a) students not valuing the content and some perceiving some content too easy or already known; and (b) disaffection for passive learning pedagogy. It also seemed that some students experienced or stated that they were bored despite what looked like may have been some engaging experiences for them and four main explanations were posed: (a) one or two students were boredom-prone; (b) one student was experiencing reactant boredom and another apathetic boredom; (c) some students were acting out due to psychological needs not being met; or (d) just banding together and enjoying a bit of anti-establishment rude fun. Additionally, in Chapter 6: Classroom Tensions — When Researcher Assumptions Meet Classroom Realities, other situational and unexpected sources of apparent disaffection were identified: (a) students apparently not wanting to assess or be assessed by known peers; (b) students seemingly expressing feeling infantilised by some DLOs and activities; (c) some students not liking computers; (d) networked computers taking a long time to warm up; and (e) logging in problems. Together, these findings form a contrasting backdrop to another apparent phenomenon: the students, at times, appeared to be engaged.

# Chapter 8: Engagement — 'the funner stuff like stop motion and all that'

In this chapter, the last of three results and discussion chapters, I present and discuss the learning activities or conditions which the students seemed to find engaging or which the two teachers (Serena, the expert mathematics classroom teacher; and myself, the researcher/presenter) observed that the students seemed to find engaging.

## 8.1 Signposting this Chapter

The findings are discussed in three sections: (a) working; (b) creating animations; and (c) a concluding lesson plenary involving a gradient-teaching device and differing perspectives.

In section 8.2 Working, I examine the exit slip responses to the prompt, 'I was most engaged when I was…' and present evidence of a surprising theme that emerged.

In section 8.3 Creating Stop-Motion and Digital Animations, I discuss responses from exit slips, the questionnaire and the focus group discussion which seem to show that making stop-motion animations was engaging for many students and that some students seemed engaged when creating the digital animations. In this study, the digital animations were more cognitively demanding than the stop-motion animations with concrete manipulatives.

In section 8.4 Gradient Teaching Device, a Lesson Plenary and Different Perspectives, I present evidence and discuss that although both adults — the expert mathematics classroom teacher (Serena) and the researcher/presenter (me) — thought the plenary discussion was cognitively engaging for the students, that perception of apparent engagement was not explicitly reflected in the students' exit slip responses.

In this chapter on what were seemingly engaging conditions, activity characteristics and activities for the students, as with the previous two findings and discussion chapters, I draw upon self-determination theory (Deci & Ryan, 2000), expectancy value theory (Wigfield & Eccles, 2000) and the control value theory of achievement emotions (Pekrun, 2006). I discuss the findings in relation to these theories and the theoretical framework of this study which have helped me understand, ponder and grapple with the complexities of the students' apparent engagement in learning.

## 8.2 Working

The students involved in this study were not asked to explain their understanding of the word engagement, or any other term, but it has been interesting to speculate from their responses what it might seem to mean to them. Before this study, I assumed interactive class discussions, learning new concepts or skills, playing games and being involved in hands-on activities would be thought of as engaging by students.

In this study, many students reported that they were most engaged when 'working'. or doing or writing (51% in total), and when creating digital objects for the e-learning module, that is, creating stop-motion animations, digital animations, digital images and videos (14%). A further two responses (3%) seemed show engagement in other ways: 'Listening and contributing'; and 'in front of the class'. Please refer to Table 8.1 which shows a breakdown of the students' responses to the prompt 'I was most engaged when I was…' and the thematic categorisation of those responses.

It seems worth noting that a sizable minority (32%) responding to the exit slip engagement question seemed to state they were not engaged in the intended learning activities, either disengaged (13%), probably disaffected (10%) or were most engaged when socialising (9%). Considering that the prompt asked when the students were most engaged, these responses might especially indicate rather strong disengagement and disaffection or possibly a strong need to express dissatisfaction. Nonetheless, most students seemed to report some engagement and this chapter explores the activities and conditions which many students appeared to find engaging or perhaps associated with engagement.

Table 8.1

*Themes from Exit Slip Responses (n = 69) to ‘I was most engaged when I was…’*

| Theme | Percent* | Illustrative examples |
|---|---|---|
| | Categorised as engaged | |
| Total engaged | (68%) | |
| Working in total | (51%) | |
| General classwork | 41% | ‘working’ |
| | | ‘working in our books drawing a shape’ |
| | | ‘showing equivalent fractions’ |
| Group work | 6% | ‘working with group’ |
| Computer work | 4% | ‘on computer doing the overview’ |
| Creating (digital objects) | 14% | ‘making stop motion’ |
| | | ‘making a video’ |
| Other engaged | 3% | ‘in front of the class’ |
| | | ‘Listening and contributing’ |
| | Categorised as not engaged | |
| Total not engaged | (32%) | |
| Disengaged | 13% | ‘doing nothing’ |
| | | ‘Asleep’ |
| | | ‘Never’ |
| Probably disaffected | 10% | ‘I don’t know’ |
| | | ‘Living’ |
| | | ‘stuff’ |
| | | ‘having a conversation about dice’ |
| Socialising | 9% | ‘Talking’ |
| | | ‘wheeling around, talking to friends, messing around’ |

*Note*. *Rounded to whole percentages. The 69 responses were pooled from five lessons.

Across the study, students' self-reported engagement level ($n$ = 69) from the exit slip Likert scale responses ranged from 1 'not at all' 1 ($n$ = 17) to 5 'all or nearly all of the time' ($n$ = 6). Please refer to Figure 8.1 to see the frequency of the students' self-reported engagement level types across all the exit slip responses.

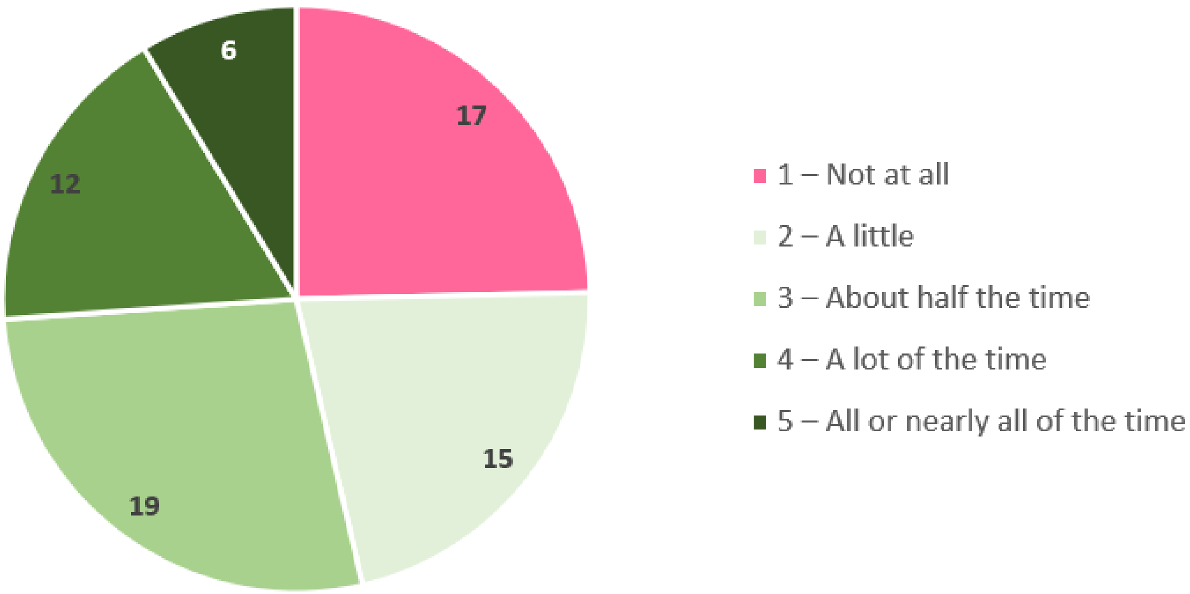



*Figure 8.1.* Proportions of Year 8 students' Likert scale responses ($n$ = 69) categorised by response type, over five lessons, to the exit slip prompt 'I felt engaged in today's session'.

Students' mention of 'working' in relation to engagement was interesting in that it not only was outside of the researcher's expectations but working does not seem to be specifically mentioned in the literature as a component of engagement. None of the definitions of engagement reviewed in Chapter 4: Defining Engagement and the Theoretical Framework defined engagement in terms of 'work'. Rather it seems that on-task behaviour is part of, and a measure of, behavioural engagement (e.g., Li & Ma, 2010; Reeve, 2012) and that this appears to incorporate 'working'.

The students' reporting of most engagement when working was widespread in this data set and not confined to one activity, one lesson or just to the students reporting being strongly engaged or any other level of engagement. This might infer that a need was being met (in that needs apply universally) when students perceived themselves to be working. Perhaps, in line with self-determination theory, the students' need for competency was being met when they perceived themselves as working towards achieving something and thereby demonstrating competence? However, particularly with the anonymous one-word answers of 'working' in response to when most engaged, it is difficult to surmise what it is about working that might have been engaging for the students and whether working might have been perceived to be aligned with emotional, cognitive or behavioural engagement, or perhaps just compliant engagement. To this end, I examine the responses to the exit slips which had an extra prompt.

**Exit slips with an extra prompt: 'because…'**

Lesson 9 is analysed here because the exit slips were augmented with an additional prompt, 'because', which seems to have given some extra insight into the students' engagement when working. This addition to the exit slips was made later in the study to hopefully elicit more information from the students than their frequent one-word responses. In Lesson 11, the next and final full teaching lesson with the students (in Lesson 10 the questionnaire was administered), the original-style exit slips were unfortunately used, so the augmented exit slips were only used in Lesson 9. Please see Table 8.2 for the responses from Lesson 9 which include the theme of working.

Lesson 9 had a rotation of four activities, two cognitively challenging: (a) creating a digital animation linking part-whole and measure fractions concepts; and (b) comparing fraction pairs; and two less challenging: (a) creating a stop-motion animation title of the word 'fractions' using plastic fractions tiles; and (b) creating short videos showing equivalence in two ways.

Table 8.2

*Exit Slip Responses from Lesson 9 Relating to Work*

| Student | SR engaged level | I was most engaged when I was… | because | I was least engaged when… | because | SR learning level |
|---|---|---|---|---|---|---|
| 7 | 2 | working | | I wasn't | | 3 |
| 10 | 3 | Doing stuff | it was fun | Doing stuff on computers | i don't like it | 3 |
| Zach | 3 | doing work | it was good | not doing work | it is friday | 3 |
| 14 | 4 | doig stuff | I was doing stuff | I wasn't doing stuff | I wasn't doing stuff | 3 |
| 15 | 4 | working | I was Doing something | Someone stole something | it was mean | 4 |

*Note.* Student responses are written here verbatim from the exit slips. SR = self-rated; 1 is lowest and 5 is highest. Student numbers for anonymous responses refer to the ranking based on SR engagement and learning level of the $n$ = 17 students for that lesson.

It appears from the exit slips that working was enjoyable for two students in Lesson 9: 'I was most engaged when I was…' 'doing stuff' because 'it was fun' (Ex-L9-10/17-Anon) and 'doing work' because 'it was good' (Ex-L9-11/17-Zach), but otherwise, in reference to the entire cohort of 69 exit slip responses across five lessons evidence of emotional engagement was not found in conjunction with working. However, this could be due to the exit slips only having the additional modification of the prompt 'because' for Lesson 9.

The students did not seem to pair the word 'working' with cognitive engagement by using the word 'concentrating' or similar, as Isabella did when creating the more cognitively challenging digital animation using PowerPoint on a computer (see Ex-L9-9/15-Isabella). It could be that, across the study, the tasks were not, or not perceived to be, sufficiently cognitively demanding, or perhaps were sometimes perceived as too cognitively demanding or confusing and avoided. Regardless of the possible reasons, neither in Lesson 9 nor across the study, did the students' exit slip responses combine the word 'working' with words that might indicate cognitive engagement. This seems to suggest that working for the students was mainly associated with behavioural engagement.

In the students' exit slip responses to Lesson 9 which involved the use of the words 'work' or 'working' or those that seem to be thematically aligned (e.g., 'doing stuff'), there does not appear to be the sense that working was effortful for them or related to learning. However, in each of the four activities of Lesson 9, something was asked to be produced — a stop-motion animation, a digital animation, a video on equivalent fractions and a worksheet on fractions comparisons to be completed, so working for the students might have meant being productively active or simply involved in on-task behaviour.

**Work and engagement**

Reeve (2012) has argued that engagement has an extra more purposeful, agentic component as well as the behavioural, cognitive and affective components. There is perhaps a sense that the students' use of the word 'working' (most often as a one-word in response to the question of when most engaged) falls short of the energy for and persistence in learning in Reeve's definition and that of engagement by Skinner and Pitzer (2012, p. 24): 'engagement refers to energized, directed, and sustained action, or the observable qualities of students' actual interactions with academic tasks'. Regarding student engagement with academic work, Skinner and Pitzer define engagement as 'constructive, enthusiastic, willing, emotionally positive, and cognitively focused participation with learning activities in school' (p. 22). The findings of this study suggest that perhaps the students' conception of both engagement and working were perhaps most aligned with the second part of the statement by Skinner and Pitzer (2012, p. 24) that engagement can be 'the observable qualities of students' actual interactions with academic tasks'.

**Possible meanings of working and engagement for the students**

The more committed elements of engagement did not appear to be evident in most of the students' exit slip responses from across the cohort (except Isabella wrote 'concentrating' when making the more difficult stop-motion animation; Ex-L9-9/15-Isabella), and none of the uses of the word 'working' was, as assessed by me, associated directly with cognitive commitment. It could be that 'working' for the students was a rather low energy, but positive and pleasant, activity and simply meant ‘doing something’ (Ex-L9-15/17-Anon). If so, perhaps for some students, to feel engaged meant to be pleasantly active, but not engaged cognitively or with a sense of agency and commitment. However, in the implicit context of this study which had the aim to produce elements for an e-learning module on fractions and aligned with the Macquarie online dictionary (n.d.) meaning of ‘working’ — ‘productive or operative activity’, perhaps the students felt most engaged when productively active.

It seems plausible, but it is not known, that perhaps for some of the students working simply meant on-task behaviour. For example, to the ‘most engaged when’ exit slip prompt, the responses of ‘working in our books’, ‘we were trying out quizzes and working in groups’ and ‘Writing the game instructions’ seem to suggest task-specific behaviour directed towards a learning or lesson goal. Apart from Isabella stating she was most engaged when ‘concentrating’ on creating the digital animation (Ex-L9-9/17-Isabella) and in Lesson 5 (group problem solving) one student reporting most engagement when ‘Listening and contributing’ (Ex-L5-15/17-Anon), there were no other exit slip responses which mentioned cognitive engagement and none which suggested a more sophisticated or multifaceted view of engagement. A more compelling engagement response from the students was noted in relation to creating animations.

## 8.3 Creating Stop-Motion and Digital Animations

Animation involves creating the illusion of movement by screening a succession of frames or photographs where two-dimensional (2-D) depictions or three-dimensional (3-D) objects are incrementally altered between frames. As discussed in the introduction of this thesis, throughout my broad but relatively brief experience in school classroom teaching (four years), I have seen a range of students respond positively to creating stop-motion animations. According to the extant literature, student-generated stop-motion animations seem to have been used especially in science education with undergraduate students (e.g., Hoban, 2005; Kidman et al., 2013; Macdonald & Hoban, 2009) but less so in the literature in middle years mathematics, with some exceptions (e.g., Lazarus & Roulet, 2013). Studies on stop-motion animation seem to be focused on the affordance of the approach to help students understand the content rather than focusing on engagement. In the setting of this study, amongst a background of seemingly quite widespread disaffection from the students for many of the activities, it was interesting to note the students' responses regarding apparent engagement with stop-motion and digital animation creation.

In this study, from a range of evidence, video footage, artefacts produced, teachers' observations and the students' own responses in exit slips, the questionnaire and focus group discussion, the students seemed to enjoy creating stop motion animations, although there appears to be a range expressed from tepid through to apparently keen engagement. There were two types of animations offered for students to create: (a) stop-motion animations using 3-D objects to manipulate, and (b) 2-D digital animations created with PowerPoint on a computer. The students only expressed enjoyment regarding the creation of the stop-motion animations but there was evidence that some students found creating the digital animations engaging too. In the next section, I describe the students' participation in creating stop-motion animations through the various data sources collected, from temporally distal to more proximal: focus group discussion and questionnaire responses; then exit slip responses and video evidence. The latter are described in the context of Lesson 9 where creating both types of animations, stop-motion and digital, were offered.

**Stop-motion animation responses from focus group and questionnaire**

In the focus group discussion ($n$ = 8) conducted after the main study had completed, two students, Toby and Lissy, spoke when asked about stop-motion animation. Toby thought it was 'pretty cool' and 'more than likely' that other similar students would like to do stop-motion animation. He elaborated with the following:

> Like, it was different to what we normally do in other classes… And in maths classes where we just do questions, wherever she is, *(referring to the class teacher and looking around)*, hi there, and just do bookwork. It was something different. It was good (Focus group; 26 Oct 2017; t = 2:07).

Toby seemed to value stop-motion animation for its novelty, whereas Lissy seemed to appreciate making a stop-motion animation for the intrinsic motivation of understanding the fractions concepts. When asked about making an animation on the computer showing that increasing the denominator decreased the value of the fraction, Lissy said, ‘It helped me understand fractions’. With help from her friend, Kate, Lissy worked for nearly 15 minutes on finishing the PowerPoint animation in Lesson 11 and only stopped when the power went out (Classroom video; 21 Jul 2017; t = 11:54 to 26:17). This task involved creating frames for an animation that showed a link between both part-whole and measure concepts of fractions and used division of a number line and of a circle into decreasing unit fractions.

When asked if stop-motion animation should be included in a similar project with similar students, other students in the focus group seemed to concur that others would like it by nodding in agreement (noted at time of interview; Focus group; 26 Oct 2017; t = 10:41 to 11:00). Although apparently not a resounding commendation for fellow Year 8s to have stop-motion animation included in their mathematics lessons, nodding could be interpreted as agreement, but more evidence is required, and available.

Some questionnaire responses also seemed to show that students thought creating stop-motion animations was enjoyable. None of the questionnaire prompts specifically asked about stop-motion animation, so both student responses about stop-motion animation were unsolicited, and each was positive regarding this activity. Referring to Table 8.3, the two students’ responses seem to indicate that they did not quite understand that the question prompt was asking about aspirational digital learning objects or those already available for students through Scootle, but nonetheless the responses seem to indicate that making stop motion animations was liked by these students.

Table 8.3

*Questionnaire Responses Which Mentioned Stop-motion Animation*

| Student | The digital learning objects that I would find effective for my own learning of fractions would… |
|---|---|
| Qs-D-Anon | be filming video's [sic] and stop motion. |
| Qs-E-Anon | be the funner stuff like stop motion and all that |

The retrospective responses from the students from the focus group discussion conducted three months after the lessons concluded and from the questionnaire conducted in Lesson 10, seem to indicate a liking for and engagement in making stop motion animations. As discussed below, the exit slip responses and video evidence also largely seem to confirm that creating stop motion animations was engaging for the students. However, there were two types of animations which the students created: one most students seemed to like, and another, which seemed to evoke a different response.

**A lesson with two types of animation**

Two types of animation were offered to the students in Lesson 9: one using a digital camera mounted on a tripod taking photographs of concrete manipulatives moved between frames, that is, stop-motion animation; the other using PowerPoint with digital objects moved between slides, that is, digital animation. The latter involved Year-8-level calculations to determine angles of unit fraction sectors of a circle and successive divisions of a 11.3 cm number line.  As described in the methodology section, both these simple animation creation methods were chosen based on the likelihood that teachers would have access to and be familiar with these setups.

Lesson 9 was conducted as a rotation of four 8-minute activities for the students to complete in groups:

1. Creating a stop-motion animation title for the e-learning module of the word ‘fractions’ using concrete manipulatives (plastic fractions tiles);
2. Creating 10-second videos showing both the concrete and mathematical truth of fraction equivalence;
3. Creating a digital animation in PowerPoint linking two fractions concepts by depicting sequentially decreasing unit fractions; and
4. Comparing a mixture of 20 easy, medium and hard fraction pairs in a worksheet.

The video evidence for Lesson 9 suggests that most students appeared to be at least somewhat engaged in the lesson, but especially when making the stop-motion animation using concrete manipulatives.  However, based on video analysis, there were two students who did not appear to be engaged. Hunter appeared to actively not engage in the lesson (despite apparently engaging in earlier lessons and despite encouragement); he sat in a chair rocking and refused to move to each station with his group. Another student, Nathan, appeared to have taken an object from another student causing a commotion and largely did not engage in the activities. Also, some students appeared to take on a more passive role and seemed to watch others take part in the activities. Nonetheless, most of the students appeared to listen to instructions, looked at the objects they or their friends were manipulating, appeared to be co-operating to make the animations, had some conversations about the activities and most wrote on the fraction comparison worksheet in a manner consistent with the lesson’s aims.

Considering most students produced the digital objects requested (please refer to Table 8.4 for student produced artefacts) and worked on the fraction-comparison questionnaire in the lesson, this adds to the plausible conclusion that students were mostly behaviourally engaged, or on-task, in the lesson and engaged in making the animations, particularly the stop-motion animation.

The exit slip responses from Lesson 9 seemed to show a range of engagement. At the lower end, it appears that three students were not engaged at all with a SR Likert scale engagement rating of 1. Please refer responses from Students 1 (Ex-L9-1/17-Anon) to 3 (Ex-L9-3/17-Anon) of Table 8.5. Also, Student 16 (Ex-L9-16/17-Anon) wrote a high rating for engagement of 5 for 'Living' which seems to indicate the lesson's activities were not engaging for that student. A fifth seemingly disaffected student (please see Student 12 of Table 8.5, Ex-L9-12/17-Anon) puzzling rated that he/she was engaged for about half the lesson (Likert rating of 3 for engagement) but the written responses seem to show disengagement or strong disaffection with a reiteration of 'the whole time…it was boring' across the responses regardless of the prompts. All other students seemed to be engaged from a little of the time (a Likert SR of 2) to all or nearly all of the lesson (a Likert SR of 5).

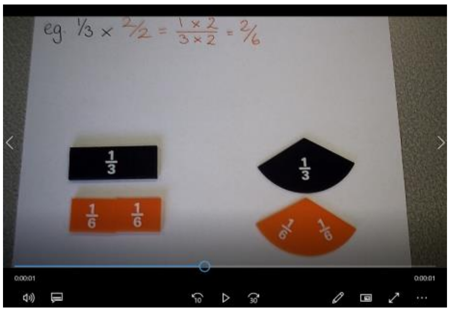
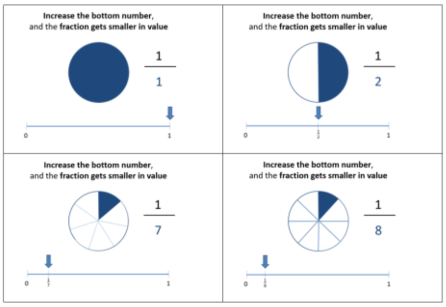
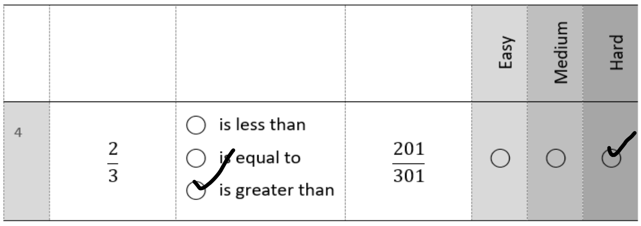
It appears that the activities which involved creation of digital objects using concrete manipulatives, that is, creating a stop-motion animation of the word 'fractions' as a title for the e-learning module and, for one student, creating very short videos (<10 s) showing the mathematical and concrete verity of fraction equivalence were valued by the students as being easy or fun. Please refer to Table 8.5 to see the responses of the students and the themes associated with them. As well as being an authentic task in the context of the class project of creating an e-learning module, the numeracy requirements in the creation of the fraction word title were spatially orienting of the fraction pieces and logically working out which pieces might best make each letter (working out, for example, that $1/12^{th}$ pieces could be used to make the 'S' [see response from Siobhan, Table 8.5] and the whole, represented as a solid square, needed to be used for representing the 'O'). Nonetheless, the mathematical and cognitive demands for creating this stop-motion animation were relatively low.

Unfortunately, when students were making videos of the verity of concrete and mathematical equivalence for Activity 2 of Lesson 9, the students left their workings for the next teams, so, as evidenced in the classroom video, students in all but the first rotation were not apparently engaged in that activity as they did not need to cognitively engage to complete the task. So, the cognitive demands for this task were, for most of the students, low as well.

It appears that the animation conducted on the computer using the presentation software, PowerPoint, was harder for the students to comprehend and this appeared to have affected engagement for five students. I tried to station myself close to this activity to help the students to start and to scaffold them across difficulties, but I missed some students and others did not seem interested. That activity appeared in five responses for the prompt ‘I was least engaged when...’ and seemed to be disaffecting because either the student seemed to have a predilection against computer work (please see responses from Student 10 of Table 8.5; so Ex-L9-10/17-Anon), was apparently boring (Student 5 of Table 8.5, Ex-L9-5/17-Anon), or was seemingly confusing or difficult (please see responses in Table 8.5 from Jenna, Ex-L9-8/17-Jenna; Siobhan, Ex-L9-13/17-Siobhan; and Student 17, Ex-L9-17/17-Anon). However, for Siobhan and Student 17, although their comments show making the digital animation was either confusing or too hard, their overall ratings for the lesson were high with 4 (most of the time) and 5 (all or nearly all of the time) respectively.

Table 8.4

*Student-Produced Artefacts in Lesson 9 — a Rotation of Four Activities*

| Activity | Description | Student produced artefact or example |
|---|---|---|
| 1 | Making stop-motion animated title for the e-learning module of the word ‘fractions’ — using concrete manipulatives<br><br>The class worked together in successive groups to take 84 photographs comprising the finished animation |  |
| 2 | Making <10-second videos showing physical and mathematical verity of equivalent fractions<br><br>Each group produced at least one video |  |
| 3 | Making a digital PowerPoint animation linking part-whole and measure concepts of sequential unit fractions<br><br>Students completed five frames in Lesson 9 and two students, Lissy and Kate, completed the remaining frames in the next weeks |  |
| 4 | Worksheet on comparing magnitude of pairs fractions and rating difficulty level* |  |

*Note.* *This is Question 4 out of 20 from the worksheet as answered typically, and incorrectly, by an anonymous student. Question 4 is adapted from Sullivan et al. (2009). The correct answer is $\frac{2}{3} < \frac{201}{301}$. No students answered this question in the worksheet correctly.

Table 8.5

*Categorised and Sorted Exit Slip Response from Lesson 9 — a Rotation of Four Activities*

| Student | SR engaged level | I was most engaged when I was... | because | I was least engaged when... | because | SR learning level | Today I learnt about | It helped me learn when... |
|---|---|---|---|---|---|---|---|---|
| 1 | 1 | talking | it was boring | working | it was boring | 1 | fractions | |
| 2 | 1 | Never | this is boring | Every part | This is boring | 1 | Nothing | Nope |
| 3 | 1 | stuff | things | I was | stuff | 2 | FRACTIONS | JOE |
| 4 | 2 | making stop motion | it was somewhat fun | most of it | it was boring | 2 | nothing | ? |
| 5 | 2 | Making fraction word | It wasn't difficult | Computer stuff | It was boring | 2 | ? | ? |
| 6 | 2 | operating camera | ? | 20 question sheet | ? | 2 | fractions | ? |
| 7 | 2 | working | | I wasn't | | 3 | CAMERAS | TEACHERS |
| Jenna | 2 | making stop motion @ fractions | it was fun | on computer | BC confusing | 3 | Fractions | I Got help |
| Isabella | 3 | on computer | I was concentrating | when I was bored | cause it was boring and not difficult | 2 | Not really anything | ? |
| 10 | 3 | Doing stuff | it was fun | Doing stuff on computers | i don't like it | 3 | ? | ? |
| Zach | 3 | doing work | it was good | not doing work | it is friday | 3 | Stuff that I know | never |
| 12 | 3 | whole time | it was boring | whole time | it was boring | 3 | not much | not at all |
| Siobhan | 4 | building the word fractions (s) | it was easy | doing the powerpoint | I didn't get it | 3 | Fractions | using fractions |
| 14 | 4 | doig stuff | I was doing stuff | I wasn't doing stuff | I wasn't doing stuff | 3 | fractions | I was engaged |
| 15 | 4 | working | I was Doing something | Someone stole something | it was mean | 4 | fractions | |
| 16 | 5 | Living | I could take place in the activity | dead | I couldn't do stuff | 3 | | [indecipherable scribble] |
| 17 | 5 | Showing equivalent fractions | Because it was easy | I was doing the powerpoint | I didn't/couldn't do it | 5 | Fraction | |

Key

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Others help leaning | Engaged in learning | Fun, easy, good | Creating DLOs concrete | Computer work good | Computer work bad | Disaffected bored | Dis-engaged | Engaged socially | Too hard / confusing | Distracted | Too much passivity | Too easy / Already known | Other / unknown |

*Note.* Responses were sorted by self-reported (SR) engagement level, the SR learning level. The four activities on rotation were the following: 1. Creating a simple stop-motion (SMA) with concrete manipulatives; 2. Creating short videos on concrete and mathematical equivalence; 3. Creating a more complex digital animation using PowerPoint; and 4. Comparing fraction-pairs.

The high overall SRs for engagement from Siobhan and Student 17 might suggest that the apparent confusion with the digital animation activity was transitory or that being confused or challenged for them was not disaffecting (that is, did not turn them away from the overall learning aims of the lesson). Additionally, Isabella reported being most engaged in that activity because she was 'concentrating' (please see Table 8.5). Furthermore, the classroom video shows that seven students were seemingly engaged in the activity in that they leaned towards the screen, appeared to concentrate their gaze upon it and touched the screen to make or check measurements. Lastly, a few students, particularly Lissy and Kate, completed this activity over three weeks which suggests at least some engagement from those students.

Stop-motion animation was reported as engaging for many of the students and digital animation, as presented in this study, was seemingly engaging for some students. Separating the engagement into three 'classic' components of behavioural, cognitive and emotional engagement, it seems that the simple stop-motion animation of the word 'fractions' using concrete manipulatives was behaviourally and emotionally engaging in that many students spent time on-task and several students expressed, in the focus group, questionnaire and exit slips, that making the stop-motion animation was enjoyable.

It seems that making the digital PowerPoint animation of increasing unit fractions' denominators causing decreasing fraction value in three depictions — symbolic (written form), part-whole (sectors of a circle) and measure (points on a number line) — was behaviourally engaging for at least seven students (Isabella, Lissy, Kate, Toby, Zach, Logan and Jacob) for whom there is video evidence they created the frames needed for the animation. Video evidence shows Nathan, who seemed prone to not engaging in the lessons, looking at the screen and was seemingly interested in what his friend, Logan, was doing in this activity. This activity seems to have also been *cognitively* engaging for Isabella because she wrote she was most engaged when concentrating on this activity. Additionally, Lissy seemed to be showing agentic (committed) engagement because, when given a range of options the next week, she actively chose to finish the required frames with the help of her friend, Kate. Presumably, there was interest value, although not expressed in the exit slips or elsewhere, and therefore some emotional engagement, for Isabella, Lissy and possibly others who made frames for this animation.

It appears that the type of engagement was dependent on the use of hands-on materials and the cognitive demand of the task. As argued by Skinner and Pitzer (2012), activities need to be both ‘hands-on’ and ‘heads-on’ (p. 22) to be fully engaging. So, although not as popular, creating the digital animation of the two types of fractions concepts appears to have been the most fully engaging activity of the study for at least one and possibly more students.

There was another difference between the two animation activities in Lesson 9. For the stop-motion animation with concrete materials, the students had autonomy, within bounds, to create the title for the e-learning module as they chose. For the digital animation in PowerPoint, students had to keep the base elements — the circle, the number line and the vinculum of the fraction — the same size, colour and position. They needed to follow exacting instructions so that their frames making up the animation would work together seamlessly. Their depictions needed to be correct. However, students could choose which frame to work on and had to work out for themselves how to calculate, measure out and position the marker on the number line and the sector radius angle. Nonetheless, there were no creative design options for that activity.

Expectancy value theory, which holds that students evaluate their likelihood of success and the benefits and costs of engaging, seems to be able to explain why many students engaged with the stop-motion animation and some students chose and persevered with the more cognitively demanding digital animation. It appears that the likelihood of success in creating the animated title was assessed as high by the students and seeing others engage in the activity might have meant there was no social cost in choosing that activity. It appears that the students who engaged with the digital animation in PowerPoint felt that if they concentrated, they would be able to do it and furthermore appeared to value the activity. Lissy stated in the focus group discussion that it ‘helped me understand fractions’.

In Attard's (2011a) three-year longitudinal study on upper primary school students' perspectives on mathematics learning and teaching, she found that many students readily recalled that the 'good' or 'fun' mathematics lessons included 'physical activity, active learning situations involving concrete materials, and/or games' (Attard, 2012, p. 11). It seems from Attard's study that rigor, commitment and explicit cognitive engagement did not feature as important for the students to value the lessons and the learning therein. The findings here seem to align with Attard's study with upper primary aged children in that some students reported being emotionally engaged, using the words 'fun' and 'easy', when using concrete materials to create stop motion animations, cognitive engagement was only mentioned twice (Ex-L9-9/17-Isabella and Lissy in focus group discussion on understanding fractions and gradients), and rigor and commitment was only evident in one student (Lissy persisting to complete the harder digital animation) and seemingly not evident in any of the student's written or oral responses.

In contrast to the more popular stop-motion animation creation engagement, in this study one or two students seemed to demonstrate cognitive and agentic engagement when creating the cognitively more challenging digital animation in PowerPoint which involved linking two fractions concepts and the symbolic representation. That is, the activity needed to be of sufficient challenge and in the students' zone of proximal development (Vygotsky, 1986) for students to have sustained engagement.

Much of the research on student-generated stop-motion animation, relates to slow stop motion animation, coined 'slowmation' by Hoban (2005), with undergraduate science or education students (e.g., Hoban & Nielsen, 2014; Kidman et al., 2013; Macdonald & Hoban, 2009; Nielsen & Hoban, 2015). As such, those animations are more sophisticated than the simple animations offered to the students in this study. The more advanced slowmations are iterative and require knowledge of or research on the topic, planning, storytelling, storyboarding, shooting and often narration. The foci of these studies seem to be on the conceptual understanding of scientific processes, like phases of the moon (Nielsen & Hoban, 2015) or understanding the semiotic processes of knowledge construction through building an animation (Kidman et al., 2013).

The use of animation creation for increasing or engendering engagement does not often seem to be pursued in the literature in a way that is relevant for this study. Nonetheless, Hoban (2016b, p. 28), working with preservice education and science students, states that one of the reasons academics should consider using slowmation as assignments in higher education is that ‘students can be creative with content’. I suspect that it was the creative element of stop motion animation which was intrinsically engaging for the students.

The definition of creativity most used in education, according to Aldous (2007, p. 177), is ‘the production of effective novelty’. That is, something is produced, it is useful, unique and new. The stop-motion and digital animations produced in Lesson 9 satisfy all these criteria. Aldous points out that creativity in educational settings is relative to the originator. So, if students produce a solution to a mathematics problem via a new-to-them approach or a produce a project or animation which is new to them it is considered creative.

Aldous (2007) found (*n* = 405) that creativity involves three activities: ‘the interaction between visual-spatial and analytical/verbal reasoning; attending to feeling in listening to the ‘self’; and the interaction between conscious and non-conscious reasoning’ (pp. 179-180). In reference to Aldous’ first component of creativity, creating stop-motion animations with manipulatives does involve interaction between visual and spatial elements and reasoning, and as such perhaps lends itself to quickly evoking a sense to self that a creative opportunity has arisen. However, I suspect the animation activities presented did not involve the students exploring an interplay between conscious and non-conscious reasoning; the students’ responses did not indicate such involvement or an awareness. So, this study’s animation tasks appear to have been rather simple regarding creativity.

**8.4 Gradient Teaching Device, a Lesson Plenary and Different Perspectives**

Hattie et al. (2017) explain that mathematics learning is deeper and more meaningful when connections are made between topics and when students can transfer learning to new contexts. Although Beswick (2011) has queried whether the use of contextualised or real-life tasks, especially as championed in the professional literature, necessarily improves engagement per se, Hattie and colleagues argue that it is when the students themselves can make the connections and meaningfully use the mathematics to solve problems they care about that the learning becomes valuable and engaging. To this end, the final lesson of the study was designed to allow students to explore and discuss an important idea in mathematics education as part of proportional reasoning (Siemon, 2013) that when the denominator increases, the value of the fraction decreases, and that this applies across all fractions concepts. The lesson did not go as planned, but, from the perspective of the two teachers — Serena, the classroom teacher, and me, the researcher/presenter — the plenary concluding discussion session still appeared to be of value to the students and quite engaging for them. However, the exit slips from the students themselves seem to tell an intriguingly different story.

With a range of level of perceived engagement for all the lessons prior, I wondered if the concepts taught were perceived as too easy for some of the students and more students might engage if Year 8 level topics, like rates and gradients, were the focus of the final lesson. I further wondered if, as explained by Hattie et al. (2017), the students' engagement might be deepened if they were presented with opportunities to make cognitive connections between topics and concepts and apply prior knowledge to new practical applications. I had also noticed and received feedback through the exit slips that more students seemed engaged when hands-on, group-oriented activities, like stop-motion animation with concrete manipulatives, were offered.

With those aims in mind, the final teaching lesson of the study Lesson 11 was devised for the students to be able to explore and discuss the inverse proportion idea that as the denominator increases the value of the fraction decreases, and that this applies across all fraction concepts (part-whole, measure, ratio, quotient and operator), but the lesson would concentrate on part-whole and ratio fractions concepts with some mention of the measure concept. The Year 8 mathematical concepts chosen within the fractions concept of ratio were speed and gradient.

Students were to be given four choices to show the inverse proportion idea, that is, in fractions that the greater the denominator, the smaller the fraction, plus a fifth option:

1. Create a stop-motion animation to show the inverse proportion idea regarding part-whole fraction concept using concrete manipulatives (or any other way the students chose);
2. Finish the frames for the digital animation in PowerPoint showing the inverse proportion idea and linking the fraction concepts of measure and part-whole;
3. Make a video to show that as time taken to travel a given distance is increased, the speed is decreased,
    a. Students were asked to refer to the equation, $speed = \frac{distance}{time}$, and keep the numerator of distance, 10 m, the same (adapted from Vingerhoets, 2001) while experimenting with varying times (the denominator of the equation and fraction)
    b. Students were sent outside within view of the classroom and given a long measuring tape, chalk for marking the distance, a timing device (decommissioned iPhone) and a video camera;
4. Make a video to show that, with a fixed rise, as the run is increased, the gradient is decreased.
    a. Students were asked to refer to the equation, $gradient\ = \frac{rise}{run}$, and keep the rise of 1 (a 10 cm peg) the same while varying the run (the denominator of the equation and the fraction)
    b. Students were given a simple device with a base (the run) drilled with holes at 5 cm intervals, a riser peg (the rise) 10 cm in length, a variable runnel (which made the

gradient) and one large marble, one small marble, one bouncy ball and a ping pong ball (please see Figure 8.2 to see the device set at 1/7 gradient)

A fifth choice was to do the same work as those not involved in the study — worksheets and textbook exercises.

The lesson introduction, discussion of inverse proportions related to gradients and speed and the explanation of the gradient device and animation set up took just under five minutes (Classroom video 21 Jul 2017; t = 0:00 to 4:55). The whole class, barring Zach, Hunter and Jacob (who were mostly experimenting and playing with the gradient device), was involved in the demonstration of walking 10 metres in varying times (conducted half in the classroom and out the door into the corridor) and this took two and a half minutes. Explaining group roles and sorting the students into groups according to who was and who was not allowed outside without close supervision took nearly six further minutes (Classroom video 21 Jul 2017; t = 7:30 to 13:15).

Two boys appeared especially disaffected that day. Video evidence showed Hunter purposefully obscured the classroom camera's vision of the room either with the back of his head or by holding a 20-cent piece over the lens (Classroom video 21 Jul 2017; t = 10:50 to 11:39; t =12:30 to 12:45; and t = 13:06 to 13:10). At one point, he stated to his friends, 'You guys, I'm just gonna stand here for the entire class' (t = 12:30).

Nathan either sat on the floor, wandered around, scooted on the wheeled chairs, appeared to be practicing dancing or skateboard moves or engaged in kicking tricks. His behaviour seemed not destructive, but rather seemed totally unengaged with the learning activities around him. Apparently, this was not unusual for this boy. Serena told me (unrecorded conversation) she was quite worried about him and had spoken to his parents about his lack of engagement in his schoolwork on several occasions. During the lesson, Serena threatened Nathan twice with spending time in her office unless he contributed or sat down (t =17:48 and 22:36). After the lesson, Serena and I spoke about the lesson and Hunter and Nathan's behaviour. Serena said, 'The boys like that, they need to be… I think they need to be sitting down at the table, just saying don't move; just do the work' (Teacher interview 21 Jul 2019; t = 3:00).

The implementation of the main part of the lesson had to be altered. Understandably it seems, Serena, the classroom teacher, thought that allowing some boys to be outside only supervised through the window of the classroom might give those students too much leeway to misbehave and act irresponsibly. So, the outside activity was only offered to a group of girls with the intent of a rotation for some boys if time, the latter of which ended up not happening. This meant that some boys had one choice taken from them. Information was not directly gathered about whether the boys who wanted to go outside seemed to resent this or not.

*Figure 8.2.* Photograph of gradient teaching device with a variable runnel and run but a fixed riser.

The main lesson did not go as planned. Based on the video evidence and Serena and my observations there seemed to be a range of both engagement and effectiveness of execution from seemingly strong to not apparent. From the vantage point of the classroom window, Serena and I saw that the girls outside did appear to explore speed as distance over time, keeping the distance (10 metres; the numerator) the same and varying the time (the denominator) and therefore the speed, but they forgot to video and record their findings. The group of three boys tasked with videoing their trials involving the gradient device did not make a video as requested. Zach conducted over 20 trials himself with the gradient device using different balls (marble, ping pong and bouncy ball) and different gradients. When Zach had the device at its steepest (gradient of 2), Hunter took the ping pong ball and bounced it off the gradient and caught it several times (t = 20:10). He used the group's video camera to record people's faces and knees, the floor and me telling him to stop recording (Student video ZOOM0005; 34 seconds duration) but did not make a recording of the gradient device in action. Hunter walked around the room and wheeled around on the chairs. Although he was cautioned by both Serena and me, I was surprised at the extent of his apparently unengaged behaviour from the video. Considering he deliberately stood in front of the camera on several occasions (which I did not see him doing at the time), it appeared that he wanted me to know about his disaffection. (Before the next class, the post-test, he was not allowed into the classroom until he apologised; he did not seem able to explain why he was so apparently agitated.)

Three students, Logan, Ethan and Samuel, created a stop-motion animation to show inverse proportions in relation to the part-whole concept of fractions. They finished the animation consisting of 32 frames of decreasing fractions (e.g., one whole, then two halves, then three thirds etc.) sequentially filling and then exiting a whole. Logan, who mainly took the digital photos for that activity while Ethan and Samuel arranged the manipulatives, was the only student to put his name on his exit slip that lesson and rated that he was engaged all or nearly all of the time (a rating of 5), and he stated he was most engaged when 'taking photos' and learnt about 'denominators in fractions' (please refer to Table 8.6 *Categorised Exit Slip Responses from Lesson 11* to see these responses in context).

However, despite requests by Serena and me and the opportunity to do so, two other boys in that group, Nathan and Toby, did not contribute strongly. Toby sometimes seemed interested in his group's animation, for example, at the beginning he engaged in a conversation about what would happen, cinematographically, if the base and referent whole was allowed to slide around between shots and he helped tape the background for the group's animation down to the table, but mostly he chatted with Nathan, who as described above, appeared to have his focus elsewhere.

Lissy and Kate completed the remaining frames of the digital PowerPoint animation linking measure and part-whole concepts with symbolic representation. The video evidence shows Lissy measuring and moving digital objects on a computer screen from t = 11:53 until the classroom video ceased (due to a power failure) at t = 26:17. Kate helped from 11:53 till 23:00 and left to go outside to be with the her friends tasked with making a video showing the inverse relationship between time and speed.

Table 8.6

*Categorised and Sorted Exit Slip Responses from Lesson 11 — Four Hands-on Activities on Inverse Proportions*

| | Student response | Engaged SR | Most engaged when... | Least engaged when... | Learning SR | Learnt about... | It helped me learn when... | Learning was interfered when... |
|---|---|---|---|---|---|---|---|---|
| 1 | Ex-L11-1/9-Anon | 1 | Never | Yeah | 1 | things | No | Yeah |
| 2 | Ex-L11-2/9-Anon | 1 | ? | ? | 3 | ? | ? | ? |
| 3 | Ex-L11-3/9-Anon | 3 | outside | listen | 2 | Nothing | | |
| 4 | Ex-L11-4/9-Anon | 3 | working | | 3 | | | |
| 5 | Ex-L11-5/9-Anon | 3 | working | | 3 | measuring | | |
| 6 | Ex-L11-6/9-Anon | 3 | doing work | not doing work | 3 | Stuff | We did stuff | People did stuff |
| 7 | Ex-L11-7/9-Anon | 4 | Doing the powerpoint | | 4 | Fractions | Kate was helping me | |
| 8 | Ex-L11-8/9-Anon | 4 | I did stuff | idk | 4 | Fractions | quiet | here |
| 9 | Ex-L11-9/9-**Logan** | 5 | taking photos | | 4 | denominators in fractions | | |

Key

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Engaged | Creating | Others help learning | Distracted | Disengaged | Disaffected - bored | Too much passivity | Computers good |

*Note.* Responses sorted by self-reported (SR) ratings (1 – low to 5 – high). Lesson 11 consisted of four hands-on activities on denominators in fractions in the context of speed, gradient and part-whole fraction concepts.

The students were called together to discuss their findings and view the videos they were to have created. Unfortunately, the power had gone out, so the classroom video camera did not capture the concluding plenary of the lesson which was going to be a viewing and discussion of the two student-produced videos. The power outage also meant the classroom screen monitor was not working. However, the students did not produce the videos anyway. The plenary became a demonstration and discussion of the gradient device in action and discussion of the 'the greater the denominator, the smaller the fraction' in multiple contexts instead.

**An engaging concluding plenary — or was it? What the teachers thought**

Serena and I interpreted the students' actions and discussed together that the students were mostly engaged for the concluding plenary session of this lesson, which aimed to link two fractions concepts, part-whole and ratio, with the idea of inverse proportions — common to all fraction concepts. From my notes, there were four moments that evidenced engagement.

The first incident of apparent engagement was when asking the students to predict which gradient would send the largest marble the furthest. After each student, including Hunter and Nathan, had made their verbal prediction, two students adjusted the device and sent the marble down the runnel for each guessed slope. Markers were placed at each distance attained. It was determined that a gradient of 1:1.5, that is, having the peg riser (with a value of 1) at the 1.5 position (so a gradient of 2/3, 0.67 or 67%), sent the marble the furthest. The students seemed interested to know which gradient would send the marble the furthest by each having a pre-claimed stake in their assertion. This seems in concert with the discussion by Lim, Buendia, Kim, Cordero, and Kasmer (2010) and finding by Kasmer and Kim (2012) that using prediction in the mathematics classroom increases cognitive engagement because the students need to visualise the imagined scenario, make connections and engage in reasoning — in this case discern between alternatives.

Secondly, the students seemed to be engaged when the question was posed as to why the steepest slope did not send the marble the furthest: 'Time was allowed for the students to respond. Class listened to each idea. Isabella eventually said that the energy went into the bouncing not rolling' (Researcher notes; 22 Jul 2017). The students seemed to be cognitively engaged in the query and, in a discursive practice (Goos, 2004), seemed to want to explore the possibilities and listen to each other as found in studies of inquiry-based learning (Fielding-Wells et al., 2017) in the discussion phase of inquiry (Pedaste et al., 2015). Within an expectancy value theory framework, Fielding-Wells et al. (2017) found that students were cognitively engaged in a unit of inquiry because the students were able to surmise that they could do the task, valued it and could draw upon each other to explore ideas. Similarly, but on a micro scale, the students in this study for this activity seemed to be able to make suggestions without fearing mistakes (not everyone was going to be right about their predictions), value the inquiry itself, value the class discourse and contribute.

Thirdly, the students seemed to be engaged when asked how to work out the gradient when the rise and the run were known. I started with a query about the gradient when the rise and run were both one and rephrased to ask, ‘What is one divided by one?’:

> About one third of the class said in unison ‘One’. No one was fiddling, chatting or rocking. Students were looking at me or at the device. The sense of the room was that we were all together and inquiring together (Researcher notes; 22 Jul 2017).

The students appeared to be engaged because they were quiet, not moving or calling attention to themselves. Their gaze was directed at me or the device, not because I or the device was interesting, but because the students seemed to be concentrating on the ideas. This seemed to be a quiet, interested engagement which I had not experienced with that class before. I wrote, ‘It was like looking into the eyes of a wild animal. I wanted to hold the moment and slow my breathing’ (Researcher notes; undated).

A fourth apparently engaging moment was when I asked if the rise is still one and the run is one half, what would be the gradient. Hunter, called out confidently, ‘Half!’ and I asked him to rethink (Researcher notes; 22 Jul 2017). Ultimately, after showing one whole divided into halves on the board and asking, ‘What is one how many halves?’ it appeared that many in the class seemed to understand that the gradient for 1/0.5 would be 2. Again, it appeared that the students were cognitively engaged in the discussion. Time was running close to the end of the lesson, so the plenary finished with a brief discussion on how if the denominator of a fraction increased while the numerator remained constant, the value of the fraction decreased regardless of the context.

It appears from the teacher interviews that Serena, the expert mathematics classroom teacher, also thought her class was engaged for the plenary discussion at the end of Lesson 11 based on the gradient device and fractions. From the interviews it seemed Serena valued the device for helping the students understand fractions and gradients and thought it helped the students see and explore the mathematics concepts in a practical and applicable way. Please see Table 8.7 for illustrative quotes from Serena.

Table 8.7

*Two Interviews with Serena about Gradient Teaching Device*

| Theme | Directly after lesson<br>21 Jul 2017 | Five months later<br>17 Dec 2017 |
|---|---|---|
| Engaged or involved | But they've got an idea of what the gradient is and how the… rise and run can affect the gradient. That is one good thing. It was good… most of them are really involved. (01:00) | Most of the students were really engaged in that one. (11:30) |
| Understanding | They really understood it, most of them, especially when you increase the horizontal distance, the run, then what happens to the slope. Yes… so, they understood. (00:30) | |
| Exploring | | They were just exploring something. (12:30) |
| Everyday life | | I think they were learning something really, you know, related to everyday life. (12:31) |
| Practical and concrete | | They know the concept of gradient, but [this helped] in a practical way. Yes, it's not abstract thinking and learning, they're viewing it and it's a concrete thing. (12:40) |
| Useful at school | Yes, it was great. It was really good. I think we need that at school.<br>(06:15) | Yes, I really, really appreciate that one, if it is available. That's a good way of showing them the concept of grading… And fractions. (06:30) |

It seems that what Serena and I, as the teacher and researcher/presenter respectively, agreed upon implicitly was that when students were listening, asking and answering questions and having conversations about the content, that is, when apparently cognitively engaged, that the students were deeply engaged. One student, in one lesson much earlier (Lesson 5, Group work, 19 May 2017), wrote that he/she was most engaged when ‘Listening and contributing’, however, for most students in this study and for the plenary discussion at the end of Lesson 11 on the gradient device, denominators and different fractions concepts, it appeared that the students reported feeling most engaged when working, or behaviourally engaged, and did not report being cognitively engaged.

**An engaging concluding plenary — or was it? What the students wrote**

The exit slip responses from the students did not show evidence that the plenary discussion which included predicting, discussion, mathematical reasoning and exploring inverse proportions was the most engaging part of the lesson for the students. Rather, two students reported being disaffected for the whole lesson (Students 1 and 2; Table 8.6) and one student (Student 3; Table 8.6) reported that he/she was least engaged when listening. Please refer to Table 8.6 to see the students’ exit slip responses to Lesson 11.

Captured on video before the power went out, four students did not appear to work towards the lesson’s aims. Although Hunter and Jacob used the gradient device to roll a toy car (from Hunter’s pencil case) down its slope and bounce the ping pong ball off the surface, this exploratory play did not lead into an investigation of gradients or the production of an explanatory video on fractions and gradients. Indeed, Hunter seemed disaffected and stood in front of the classroom camera making faces and blocking its view. Nathan and Toby were on the animation team but did not contribute to its construction. Nathan used the time to perform what looked like dance moves and kicking tricks. Toby walked around the room chatting. Whereas Jacob and Toby appeared to be tuning out, Hunter and Nathan appeared to be acting out. Drawing on Skinner and Pitzer (2012) and self-determination theory their behaviour tends to suggest that these students’ psychological needs were not being met. ‘When these needs are thwarted people become disaffected, that is, they withdraw, escape, or act out' (Skinner & Pitzer, 2012, p. 27). It was not clear why Hunter and Nathan seemed so disaffected. However, this apparent disaffection did not stop these boys from contributing in the plenary.

As with most other lessons, many students (four out of nine) wrote that they were most engaged when working and an extra one student's response of 'Doing the PowerPoint' could be included in the theme of working. Please refer to Table 8.6 to see the students' Lesson 11 exit slip responses. What is puzzling here is that it is not clear what working meant for the students in this context with the gradient device. Perhaps for Student 5 of Table 8.6 working meant measuring. Would the students think that walking and timing their walking over 10 metres was work? Would manipulating plastic pieces for a stop motion animation be work? Perhaps listening and contributing to a class discussion was work? There is not enough information to know.

The exit slips were completed in a rush at the end of a lesson which needed to be altered due to a power failure. The hurriedness of the answers can perhaps be seen in the shorter than usual responses and perhaps in the greater than usual number of blanks. Only nine of the 14 students present completed an exit slip. In other lessons, all students present completed an exit slip. It is not known whether most students did not respond with anything for the prompt 'I was least engaged when…' because there was not time to fill it in or if this might be an indication of higher engagement, that is, nothing was particularly disengaging for those students. Also, in contrast to other lessons, none of the students wrote about being socially engaged, being confused, the content being too hard, already knowing the content or being distracted (except that 'quiet' for Student 8 seems to infer that at times the class was noisy). None of the students used the word 'boring'. However, it is not known whether these conditions were not evident in the exit slip for Lesson 11 because those conditions were not present or whether there was not enough time to express those responses that were prevalent in previous lessons (please refer to Appendix G for all the exit slip responses both in date order and then as sorted by SR engagement and learning level). The exit slip table for Lesson 11, Table 8.6, is not directly comparable to that for Lesson 9, Table 8.6, because the older type of exit slips without the extra ‘because’ prompts were distributed in Lesson 11.

Without the video evidence to check the end of the lesson, it is not clear how many students were apparently cognitively engaged in the plenary, that is, asking or answering questions or making predictions about which gradient would send the marble the furthest. I suspect Students 1 and 2 (from Table 8.6) were more engaged during the plenary than they recorded on their exit slips, but apart from Serena’s responses, I do not have evidence to back up this intuition. On the other hand, Serena stated that most, not all, students were engaged during the plenary. Furthermore, there is ample video evidence of some students apparently amusing themselves in either mildly disruptive, social or rather off-beat pursuits for the main part of lesson and seemingly not engaging in the learning aims, so the exit slip responses might accurately reflect the engagement of the students. Countering this, there is something perhaps pointed in filling in an exit slip and rating that the lesson was not at all engaging. There seems to be a communication behind this — a willingness to let me know or state they were not engaged. Perhaps some students had fostered a ‘boring’ narrative and wanted to perpetuate it? It is not clear why some students were disaffected or perhaps wrote they were disaffected.

What is clear is that the students’ exit slip responses do not match the perspectives of the researcher/presenter (me) and the classroom teacher who both reported that the apparent learning from using the gradient device and the ensuing class discussion was, from our teachers’ perspectives, worthwhile for the students. It is possible that my own enthusiasm for the gradient device affected my perspective of the lesson and even drove the questions posed to Serena. However, both directly after the lesson and five months later, Serena seemed genuinely enthusiastic about the gradient device and the ensuing class discussion. It seems plausible that the understanding and cognitive engagement derived from using the device was ‘…one good thing’ (Serena, Teacher interview, 21 Jul 2017, 1:00), but that did not seem to register as engagement for the students.

A difference noted between the teachers' and students' perspectives was that both teachers seemed to think the plenary discussion and whole class demonstration of the gradient device was cognitively engaging for the students, but none of the students noted that the discussion or demonstration was engaging in the exit slips. This could be simply that time was tight when the exit slips were issued, and the students responded according to patterns of response from previous lessons. Or it could be that the students recognised emotional and behavioural engagement but needed tuition in valuing discourse and cognitive engagement. Throughout the study, including for Lesson 11, students responded in the exit slips that they were often most engaged when working, so when actively, physically and behaviourally engaged; sometimes students wrote that they were emotionally engaged; and seldom students wrote they were cognitively engaged. Perhaps students did not recognise cognitive engagement? Or perhaps if recognised, they did not value it?

### 8.5 Discussing Findings through the Theoretical Framework for this Study

As noted in the previous chapters, the theoretical framework of this study draws on expectancy value theory EVT (Eccles et al., 1983; Wigfield & Eccles, 2000), self-determination theory SDT (Deci & Ryan, 2000), and the control value theory of achievement emotions CVTAE (Pekrun, 2006). The aim of this chapter is to explore findings from the study which suggest the students were engaged in activities. In Figure 8.3 which depicts the theoretical framework used in this study, the relevant sections for this chapter of this study are highlighted in yellow.

In the decision-making phase of the theoretical framework for engagement, described by EVT, a student who is presented with a learning task and values it, perceives that the task is achievable and evaluates that the benefits in engaging outweigh and costs, will be intrinsically motivated to achieve the learning goal, and so will engage. As defined by the working definition of engagement used in this study, derived from and influenced by multiple studies, commentaries, reviews and theorising on engagement, 'learning activity engagement is behaviour and mental processing directed towards achieving learning goals and is associated with enjoyment or interest'.

So, a proposed marker of engagement, drawing on CVTAE, is the expression of enjoyment or interest while physically or mentally working towards a learning activity goal. Undergirding the evaluation by the student of a learning task's value are the three psychological needs as described by SDT: competency, relatedness and autonomy.

In this study, many students reported being most engaged when working. This finding, although the students' definitions of engagement and working were not canvassed, seems to align with the need for competency and to describe behaviour directed towards learning goals. The implication would appear to be, referring to SDT and considering that the students were engaged, that working is enjoyable, but the findings of this study neither directly support nor challenge this.

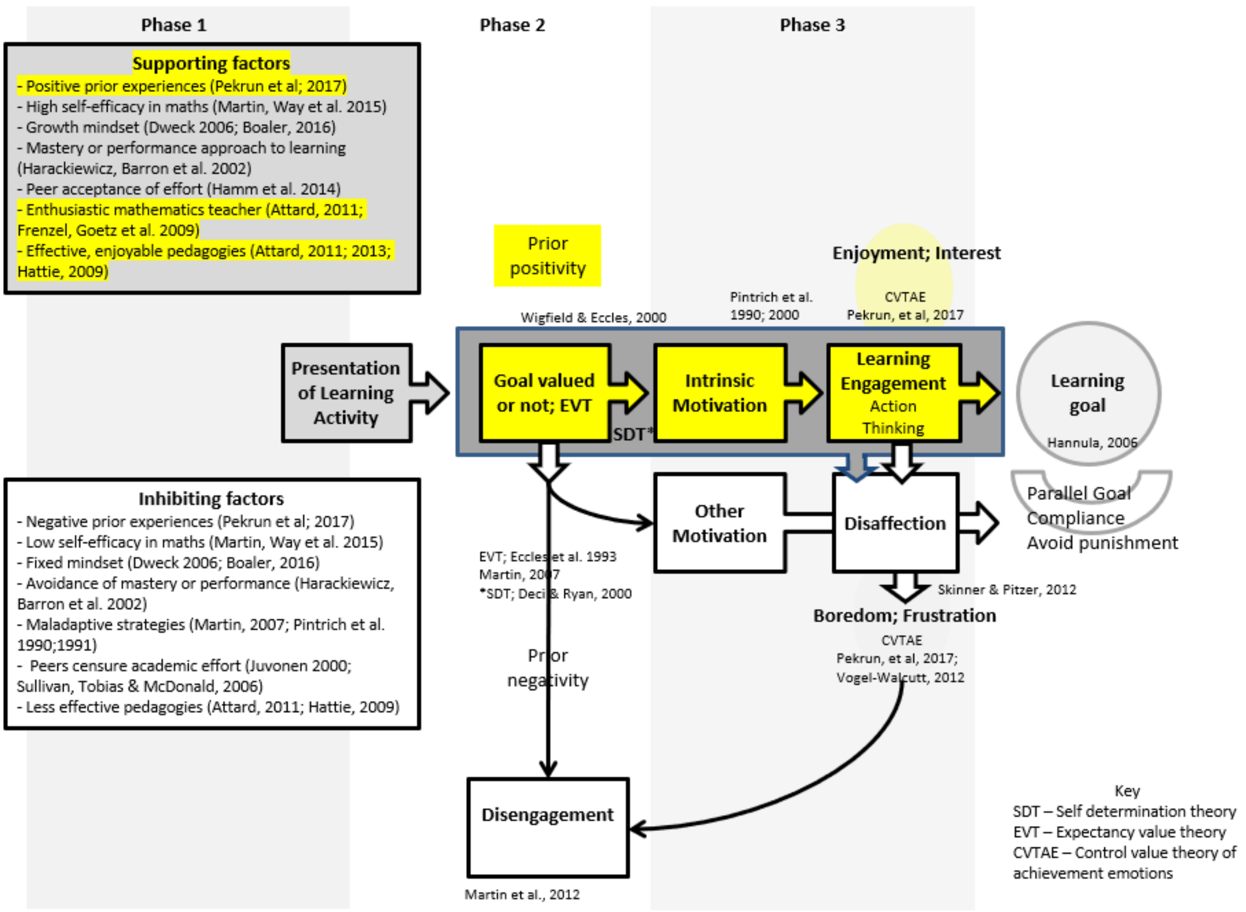



*Figure 8.3.* Theoretical framework of learning activity engagement highlighting the engagement trajectory, associated emotions and supporting factors pertinent to this study.

Another finding of this study is that many students appeared to find that creating stop-motion animations was enjoyable and engaging. According to Aldous (2007, p. 177), the definition most used in education for creativity is ‘the production of effective novelty’. This definition seems to align with SDT in that something effective is produced, so a person creating has the opportunity to demonstrate competency; the produced article is unique (for that person) so he/she has had autonomy to choose elements of its creation; and in an educational setting, presumably with favourable pedagogy and an interested teacher, the produced article is shared with and viewed by others, or possibly produced with others, thus satisfying the student’s need for connectivity and interaction. In this way, the three psychological needs as described by SDT would be supported by inviting students to create stop motion animations (or any other creative pursuit) in mathematics.

Lastly, the two teachers participating in this study, Serena and myself, noted that the students appeared to be engaged during discourse on the connections between gradients and speed, fractions as ratios, the part-whole concept of fractions and inverse proportionality. The fluidity of the learning connections ostensibly able to be made between different fraction concepts seem to support those found by Charalambous and Pitta-Pantazi (2007). In terms of SDT, making the connections between fraction concepts might have registered as demonstration of cognitive competence for the students. The discourse was a social, interactive activity. However, the need for autonomy within this scenario seems harder to characterise, except that students could elect to tune in and contribute, or otherwise. The students did not mention this activity as engaging in the hurriedly completed exit slips, but one student mentioned it as an ‘Aha’ moment in the focus group discussion. In reference to the working definition of engagement in this study, according to the teachers and at least one student, this activity seems to have demonstrated mental processing directed towards a learning goal and was associated with interest.

The theoretical framework used in this study based on EVT, SDT and CVTAE seems to have been able to explain and align with the findings, although more research would seem to be indicated to explore what students mean by working and engagement, characterising the engagement value of student-generated digital media, especially creating stop-motion animations, and exploring ways to help students appreciate engagement in mathematics discourse.

**8.6 Concluding this chapter**

In this chapter, I discussed an unexpected condition: students stated that they were engaged when working. Although not certain what the students meant by working, it was proposed that it meant being occupied in the lesson's learning aims and was aligned with behavioural engagement. It was also discussed that perhaps many students felt most engaged when pleasantly and productively active. However, the use of the word 'working' was not used with cognitive challenge by the students. Engagement as working appears to be in concert particularly with the definition of engagement by Gettinger and Walter (2012), as the 'actual involvement or participation in learning'. Engagement as working seems to align with the definition of engagement used in this study: 'engagement is behaviour and mental processing directed towards achieving learning goals and is associated with enjoyment or interest', but it was not clear if working included mental processing and cognitive engagement for the students and enjoyment and interest were not directly expressed in relation to working.

It appears that the students liked making stop-motion animations. As presented in this study, this activity seemed to be associated with fun, ease and enjoyment for the students and therefore aligned with emotional engagement. The digital animation offered to the students using the presentation program, PowerPoint, involved harder concepts — dividing a circle (part-whole concept of fractions) and a number line (measure concept of fractions) into decreasing unit fractions. Those students who worked on this animation seemed to find the activity cognitively engaging.

Finally, the class appeared to have had mixed engagement responses to Lesson 11 (similar to all the other lessons) on helping students recognise that 'the greater the denominator the smaller the fraction' idea applies across fractions concepts. The lesson included exploration of gradients and fractions with a simple gradient teaching device. The concluding class plenary discussion and demonstration of the gradient teaching device seemed to be valued by the teachers, that is, Serena, the expert mathematics classroom teacher, and me, the researcher/presenter, but was not mentioned by the students.

The lack of mention by the students of the gradient device whole-class demonstration and the ensuing discourse was discussed as possibly being due to the students having to rush the exit slips. Or in the light of an emphasis on behavioural engagement in the students' exit slip responses for when they were most engaged with 'working', perhaps the students did not recognise cognitive engagement and discourse as engagement? Or if the students did recognise their own cognitive engagement, perhaps they did not value it as much as behavioural or emotional engagement? It is also possible that some students wanted to maintain a boring narrative despite an engaging experience and, perhaps, despite being presented with some engaging learning opportunities throughout the study. Perhaps it was a mixture of all of these?

# Chapter 9: Implications and Conclusion

With a backdrop of widespread disengagement from mathematics, especially amongst early adolescents (e.g., Martin et al., 2012), in this exploratory case study I sought to gain a deeper understanding of engagement and disaffection in learning activities by being with, asking questions of and observing a class of Year 8 mathematics students and their teacher, Serena, while we worked on a project. The goal of co-creating an e-learning module on fractions was not attained. There were several situational hindrances that seemed to affect the trajectory of the project, but more so, my own assumptions were exposed in the light of classroom realities. I have learnt a lot.

As a teacher, I have learnt that engaging activities in one context do not necessarily translate to another and that for learning and teaching to be truly student-centred (not project-centred), as other researchers have found (e.g., Attard, 2014), the teacher ought listen and respond to the students' needs, abilities, aspirations and values, and not 'drive' a project. The level of challenge not only needs to be at, but perceived to be at, the students' zone of proximal development. With this group of early adolescent students, I have learnt that I needed to be vigilant about their sensitivities to juvenile material and to avoid putting them in a situation where they might be expected to judge or be judged by peers. Although the challenge of researching engagement at the activity level is that it is linked to influences beyond the task — the relationship between the teacher and the student (Attard, 2014), previous experiences, and attitudes (e.g., 'I don't like computers') — I have also learnt that some activities, like creating stop-motion animations, using age-appropriate concrete manipulatives and mathematics discourse which relates to life beyond school, seemed to be engaging for many of the students. On the other hand, passive pedagogies involving teacher explanations were not good choices for these students, even when, or perhaps especially when, the students appeared to be tired. It seems these students needed to work and be active.

The research questions guiding the study were the following: (a) 'What activities, activity characteristics and conditions seem to be engaging for these Year 8 mathematics students while co-creating an e-learning module on fractions?' and (b) 'What activities, activity characteristics and conditions seem to be boring, or otherwise disaffecting or disengaging, for these Year 8 mathematics students while co-creating an e-learning module on fractions?' In answer to the first research question, and relating strongly to what I have learnt as a teacher, both making stop-motion animations and discussing gradients and fractions when rolling a ball down a device with a variable runnel seemed to be engaging for the students and both these activities were hands-on and involved interacting with others. The activities used with the gradient teaching device, from the teachers' perspectives, appeared to be engaging, readily relatable to life beyond school and opened up avenues of mathematical discourse. The students reported being most engaged when 'working', presumably meaning for them when active.

In answer to the second question, the students seemed to find passive pedagogies, like listening to and watching a presentation, less engaging compared to more interactive, hands-on activities that also allowed a degree of autonomy. If the students could not see the value of content, they appeared to disengage from learning and express boredom. During the stuttered and stalled progression of the creation of the e-learning module the following appeared to evoke negative emotional responses from many of the students: (a) being asked to create assessments of or for known peers in perhaps a teacher-like role; (b) negative experiences with using computers in the classroom (including logging in problems and slow warm-up speed); and (c) being asked to assess juvenile-looking material. Several apparent sources of boredom were found — situational, content-value-related, pedagogical, social and perhaps within-individual. For within-individual boredom, one or maybe two students appeared to be boredom prone, that is, such individuals experience all but the most exciting and dangerous activities as boring (Farmer & Sundberg, 1986) or perhaps these students were experiencing and exhibiting reactant or apathetic boredom (Goetz et al. 2014). By deduction and using video footage, I found what appears to be evidence that some students diminished their self-reported engagement levels to below that which it seemed they experienced.

## 9.1 Signposting this Chapter

In section 9.2 Practical Implications, I discuss findings from the study which might warrant further investigation for implementation in classrooms or developed into information which may be of use for teachers. It includes consideration of addressable boredom, boredom which was harder to characterise or address, stop motion animation and the gradient device.

In section 9.3 Methodological Implications, I discuss methods used in this study which might be useful for other researchers including the use of exit slips to gather research data and using the spreadsheet program Excel to display, organize and analyse qualitative data.

In section 9.4 Theoretical Implications, I discuss the definitions and the theoretical framework used in this study and both acknowledge and query their efficacy in describing and defining what I had hoped they would.

In section 9.5 Limitations of the Study and Suggestions for Alternative Approaches, I critically examine the restrictions of the study and, where feasible, suggest alternative strategies for further research.

## 9.2 Practical Implications

In this section on practical implications, and re-noting here that as with any exploratory case study, generalisability is not claimed (Creswell, 2013), I discuss the following:

(a) Addressable apparent sources of boredom

(b) Further consideration required

(c) When students appeared to need anonymity

(d) Peer judgement

(e) Combining fractions concepts

(f) Stop-motion animation and engagement

(g) Stop-motion animation and concrete manipulatives

(h) Gradient device

**Addressable apparent sources of boredom**

Possibly the most useful overall finding of this study is that, after analyses, it seems I could categorise much of the ostensible sources of students' apparent boredom into situational, pedagogical, content-value-related, social and individual sources. From there, the sources could be sorted into those which, as a teacher, I felt I could feasibly address (within the bounds of the teaching experiences in this study) and those which I could not. This categorisation helped me, and it may help other teachers who are faced with similar student responses, to concentrate on pragmatic solutions to some of the expressions of boredom from students and not on those which were or seemed not to be amenable to teacher influence.

These are the apparent boredom- or disaffection-inducing factors which featured in the students' responses, which I considered I could improve or consider I could have improved:

(a) too much passive pedagogy;

(b) students perceived they knew the content already

- e.g., benchmarking with and visualising fractions;

(c) logging in problems;

(d) networked computers taking a long time (>3 minutes) to warm up;

(e) students seemingly feeling infantilised by juvenile content; and

(f) students apparently not wanting to judge or be judged by known peers or adopt teacher-like roles by not wanting the following:

- to create an e-learning module for known peers;
- known peers to appraise the e-learning module;
- to create assessments or quizzes for known peers;
- to assess DLOs (digital learning objects) in Scootle (the repository of DLOs linked to the Australian Curriculum) for peers.

Please refer to Table 9.1 to see implemented and potential solutions to address these factors.

Table 9.1

*Addressable Sources of Boredom and Potential or Implemented Solutions*

| Apparent source of students' expressed boredom | Potential solution | Solution/s implemented in this study |
|---|---|---|
| Too much passive pedagogy | Reduce teacher talking time and increase student activity time. Provide a substantial block of time during lessons for students to work individually, in pairs or in groups. Engage in mathematical discourse rather than teacher presentations. | Group activities<br>Think-pair-share<br>Mathematical discourse |
| Perception content known already | Present work and use pedagogy which could be adjusted to the students' zone of proximal development, e.g., rich open or challenging tasks. | |
| | Present work which is commensurate with developmental year level and challenge students to explore conceptual links between topics or concepts. | Linking fractions concepts to gradients and speed |
| Logging in problems | Train the students on how to log in successfully to a password-controlled website. Show that this is a skill they will need outside school. Train before needed in project. | |
| | Give students website URL, individual username and password on a sticky note for them to copy. | |
| Networked computers slow to warm up | Ask several students to turn all computers on as soon as class starts. | |
| | Have class discussion or other activity while waiting for computers to warm up. | |
| Feeling infantilised by juvenile content | Evaluate materials for potential juvenile appearance and modify. | |
| Not wanting to judge or be judged by known peers or adopt teacher-like roles | Re-consider activities which require students to take on teacher-like roles involving judgement of or by known peers. | |
| | (Peer-to-peer tutoring would seem to be different as it does not involve casting a judgement or assessment.) | |

**Factors outside my control**

Whilst conducting the study, two situations which I considered I could not control were (a) students being apparently tired last period on a Friday afternoon; and (b) the class having just had a term of learning about fractions and perhaps feeling saturated with that topic. Video footage showed the students looking tired on occasions, but it is not known whether this was normal for these students despite the time of day or if they were instead bored rather than tired. However, one student (Zach) wrote that he was least engaged when 'not doing work' because 'it is Friday', and some students were captured on video yawning, which suggests tiredness. In reference to potential overload with the topic fractions, none of the students wrote or stated that they were weary of fractions, so this concern may simply be my own conjecture.

**Further considerations required**

The factors which, at the time of the study, I could not readily address and for which further consideration is required were the following:

(a) Many students appeared not to value some content, for example:

  i. learning about difficulties people tend to have with learning fractions including whole number bias;

  ii. learning about the different concepts of fractions;

(b) Some students used allocated internet time to play games or surf the net instead of following the aim of the given task;

(c) Two students (and maybe more) seemed to have a predilection against computers;

(d) One or maybe two students seemed, from their videoed behaviour and from some written responses in exit slips and the questionnaire, to have been boredom prone; and

(e) Some students seemed to express boredom to perpetuate a 'boring narrative', beyond that which appeared to have been experienced, perhaps for social reasons.

A surface level solution to students seeming not to value the content would possibly have been to further explain or show why the content was of value or guide the students to research this.

However, some of the content in this study presented to students specifically related to the creating of an e-learning module on fractions. Learning about whole number bias (Lamon, 2012), might be of interest to teachers, education students and mathematics education researchers, but it is perhaps unnecessary for Year 8 students to learn this unless they are tasked with creating an e-learning module on fractions and need to create or select content to address common misconceptions. On the other hand, some students seemed to have appreciated this information for their own learning. So, it appears that helping students to value the content in this context was complex and unlikely to be have been addressed with one teaching approach.

Some students sometimes used their time on the Internet to navigate away from the sites I had asked them to explore and played games or surfed the Internet instead. Again, this would seem to be related to the students' valuing of the content and the activity in hand or possibly that gaining access to the Internet in mathematics class was a novelty. Again, I did not have strategies at the ready, apart from asking students to shut down the other sites and work on the task at hand.

With two or possibly more students seeming to not value computer work because computers 'stuff up all the time', perhaps giving such affected students plenty of good and constructive experiences with computers might have alleviated some of this perception. However, the networked computers at the school often took a long time to warm up and I was not sure what activities might help such students have rewarding experiences with computers. I had not actually expected that some students would not like computers, and it was beyond the remit of this study for me to know how to help them using researched strategies.

One, or possibly two, students seemed to be boredom prone (Farmer & Sunder, 1986). This is clearly not a diagnosis, but rather my observation which seems to fit some of the written responses and video evidence. Again, it was outside of my knowledge, field and responsibility to know how to help students who might be boredom prone, or perhaps experiencing reactant or apathetic boredom, and manage the classroom accordingly. Rather, it highlighted that this condition or set of conditions might be experienced by other students and have an impact on their learning and engagement with school, and potentially that of their classmates. The presence of students who are boredom prone, and as such seek excitement (Farmer & Sundberg, 1986) perhaps beyond that which can be feasibly and safely provided in a lesson or might be experiencing an existential crisis whereby everything seems meaningless (MacDonald & Holland, 2002), might affect mathematics classrooms, and seems worthy of further research.

Some students seemed to rate their level of engagement as below that which they appeared to experience as documented in the video footage. Although there are several possible reasons for this, including conflating tiredness with boredom, it seems the most compelling explanation is that some students wanted to maintain a ‘boring narrative’ for social reasons. It is possible that this expression was a form of anti-establishment, social bonding for these particular early adolescents. It could be that it was a bit of rude fun; that is, those students involved actually knew it could be construed as impolite to state that a lesson was boring and enjoyed the freedom and lack of consequences for doing so. It could be that these students were expressing a personal dislike of the presenter. For example, Juvonen (2000) found that middle years students would be likely to tell teachers they liked that the reason they did not do well on a test was due to low ability, but for teachers they did not like, they stated insufficient effort was the reason for poor performance. However, it is possible that no personal slight was intended, but rather that the disruption of the study, with its evolving focus and trialling of activities, was unsettling and this was communicated by some students by stating that they were less engaged than other evidence seemed to suggest.

It is also possible that expressing boredom had another intended effect. Just as expressing sadness can engender sympathy and action from others (e.g., Eisenberg et al., 1989), perhaps expressing boredom to others has an intended social effect. Students expressing boredom in a school context might be a ploy to deflect the responsibility of learning onto the teacher, perhaps conveying, ‘I’m bored, so I don’t have to do this, and you, Teacher, need to come up with something else’. However, the evidence for this is only based on my own reception of and reactions to some of the students' expressions of boredom. Nonetheless, I doubt I have been alone in sensing this type of message from students.

There are very few research papers on boredom in education, and Pekrun et al. (2010) have proposed that this is because boredom is relatively non-disruptive in the classroom and so has not garnered research focus. However, I wonder if a contributing reason to there being so little research on boredom is that receiving feedback that activities and lessons are boring is unpleasant, even painful. So, researchers may not want to subject themselves or teachers to that kind of feedback. Indeed, supporting that expressing boredom is perceived as socially hurtful, Breidenstein (2007) found there seems to be a taboo on directly voicing boredom in the classroom. It seems exploring the social effects on teachers of students expressing boredom would be worthwhile.

**Students appeared to need anonymity**

Some researchers have found that asking senior secondary and university students to create multiple choice questions within the classroom increased academic outcomes (Hardy et al., 2014; Rhind & Pettigrew, 2012; Yu & Liu, 2005). As well as wanting to complete the questionnaire and most exit slips anonymously, the finding here was that the lower secondary students in this study did *not* want to create assessments for known peers. Apparently, it would have been better to present and maintain anonymity of these early adolescent student-creators of peer-to-peer assessments, even though the assessments were to have been for informal multiple-choice quizzes in a non-consequential e-learning module. Serena suggested that the students did not want to appear dominant to peers in a teacher-like position and, on the other hand, she surmised that they did not want to be exposed as lacking in knowledge to their peers. This anxiety could possibly have been avoided by making and keeping the end-users of the e-learning module anonymous. Others have found that peer-to-peer assessments (not creating assessments but implementing them) are of significant value in aiding comprehension with middle years students (Tsivitanidou et al., 2011) if the participants are kept anonymous from each other. When I asked the students about this in the focus group discussion, they generally agreed that it would not have been a problem for them to have created the e-learning module and assessments for other totally unknown Year 8s. This finding might help teachers wanting to implement projects involving early adolescent students creating assessments in their classrooms.

**Peer judgement**

One of the early findings of the study was that some students seemed reluctant or unable to take on a teacher-like role and appraise DLOs for suitability for known peers and perceived that the many of the DLOs were infantilising. Various explanations were offered including that if a student stated that a DLO was suitable for known peers, this might set the student up for a judgemental reprisal from a peer: '*Why* did you choose *this* one?'. However, another explanation might be that there are too few DLOs on fractions for Year 8 students that allow both exploration of earlier concepts and extending challenge. Further research might uncover what, if anything, early adolescent students might fear in choosing DLOs for known peers and, separately, what DLOs in Scootle on fractions might help Year 8 students engage and grow in their learning.

**Combining fractions concepts**

It appears that combining fraction concepts, as informed by testing and SEM by Charalambous and Pitta-Pantazi (2007), and asking students to represent those connections (Hattie et al., 2017; Pape & Tchoshanov, 2001; Skemp, 2006) in the digital animation had merit in developing cognitive engagement for some students, that is, it seems the activity helped them see connections and direct their thinking towards a specific and meaningful goal. However, further research might uncover the strength of those connections, whether they were dependent on animation creation or otherwise, or perhaps just novel activities, and if any combinations might not aid learning.

**Stop-motion animation and engagement**

The students seemed to like creating stop-motion animations. Students mentioned the words 'easy' and 'fun' for these activities and one student mentioned that he learned about 'denominators in fractions' during the lesson in which he helped create an animation. So, it appears that stop-motion animation could be explored further in mathematics education both in helping early adolescent students to engage in the subject and to teach or help reinforce mathematics concepts.

Researchers have found that using stop-motion animation, or slowmation (slow stop-motion animation, coined by Hoban in 2005, used in education with fewer frames per second than usual animation) aids conceptual understanding with the following learners: (a) university science and pre-service education students (Hoban, 2016b; Hoban et al., 2011; Kidman et al., 2013); (b) pre-service education students in mathematics (O'Byrne et al., 2018); (c) primary students with mild intellectual disabilities to develop social skills (Shepherd, Hoban, & Dixon, 2014); (d) primary students learning science (Hoban, 2005), social studies and storytelling (Kiser, 2001); and (e) young children learning science (Fleer & Hoban, 2012). However, stop-motion animation does not yet appear to be well researched in secondary school mathematics education contexts for either helping students with conceptual understanding or for its effects on engagement.

Further research also could be undertaken to determine if or why stop-motion animation might be engaging in such contexts. From this study’s findings, I have surmised that it was because it is a creative task (Aldous, 2007), but it could be that an animation tells a story or that movement is involved or something else. Further research might elucidate what features of an animation task are engaging.

**Stop-motion and concrete materials**

It is interesting that some students seemed to react negatively to juvenile content when asked to appraise DLOs in Scootle but did not seem to react similarly when making stop-motion animations using brightly coloured fraction pieces that may have been associated with primary school. Perhaps the context of creating stop-motion animations may give lower secondary students ‘licence’ to revisit earlier concepts and to use concrete manipulatives in a socially acceptable manner. Further research involving creating stop-motion animation by students with gaps in their understanding of mathematics would seem to be warranted.

### Gradient device

It appears that the simple gradient device — with a fixed rise of one, an adjustable run and a variably sloping runnel for smalls balls (like marbles and ping pong balls) — may have merit as a teaching device. This apparatus, devised to show the inverse relationship between the run and gradient, was inspired by two disparate sources: (a) a YouTube video of US mathematics teacher, Kay Toliver (2008, November) with her students enjoying a tinker toy derby of vehicles they had created careening down a slope (except in this current study the variable is the slope and run, not the 'vehicle'); and (b) my past penchant for the game, Cribbage, where scoring is done with a peg in a succession of holes.

As noted above, one student in the focus group discussion said that an 'Aha' moment for her in the study was seeing the relationship between fractions and gradients. Unfortunately, the discourse on this topic was not videoed, so the responses of other students was not captured, but Serena, the classroom teacher, seemed to be a strong advocate of this novel device for teaching about gradients and fractions in a practical, hands-on way. So further research on using this device classrooms would seem to be worthwhile.

## 9.3 Methodological Implications

In this sub-section, I discuss the methodological implications of this study: using exit slips to gather data;  the use of colour-coding by theme and sorting by quantitative data order in Excel; how students' definitions of engagement and working might be further explored; and how students' valuing (or not) of mathematics discourse might be further investigated.

### Using exit slips to gather data

The exit slips used in this study were quick and inexpensive to administer and appeared to be useful in gathering brief qualitative and quantitative appraisals of lessons for this exploratory study. However, the addition of the 'because' prompt, which seemingly gave further insight into the students' thoughts, was added later in the study and the earlier exit slips returned many responses of three words or less from the students. Furthermore, the students were not canvassed about their understanding of the meaning of engagement and this might affect the interpretation of their responses. On the other hand, the students' responses seemed not incongruent with dictionary and extant theoretical understandings of engagement.

**Colour-coding by theme and sorting by quantitative data order in Excel**

A method for analysing and displaying exit slip data, sorting by quantitative data order and using themed colour-coding in Excel, was trialled in this exploratory study. Please refer to Appendix G which first shows the exit slip data from the lessons sorted by self-rated engagement level and then learning level, and colour-coded by theme, and then shows the entire cohort of exit slip responses ($n$ = 69) sorted by students' Likert-scale self-evaluations of engagement level then learning value for the lesson. Displaying responses with colour-coded themes and sorted by quantitative, Likert-scale data has allowed patterns to be seen and compared across lessons and has seemed appropriate for displaying and helping to analyse the short responses and quantitative data in the exit slips. This method has also allowed sense making of anonymous responses within each lesson.

In other qualitative studies, when the participant's identity is known to the researcher, responses can be sorted by participants' (deidentified) names, and an individual response profile can be built, and thematic patterns can be noted across the study for each participant. However, with anonymous data, sense making cannot be pursued in this manner. Therefore, sorting the exit slip data within Excel by the quantitative data and colour-coding the response cells by theme was the strategy used for making sense of the data within lessons and when pooling the entire cohort. This approach, which included both quantitative data and responses to open questions, might be useful in other studies involving anonymous participants over time.

**Working is engaging — but what does that mean?**

'Working' was the most frequent theme and one-word response from the students to the exit slip prompt, 'I was most engaged when I was…'. It seems feasible, that when taken in context of a classroom, that for the students, ‘working’ meant actively occupied in the lesson’s aims and activities, but this is not certain. Would students think that being involved in a discussion is working? Would students think that creating a stop-motion animation is working? Does working mean that something must be produced — like a piece of writing, a drawing or a completed problem? This finding is intriguing but has uncovered more questions.

In this study, students were not canvassed for their understanding of the term ‘engaged’. It also appears that questioning students about their definition of engagement and working has not featured in mathematics education literature.  Further research would seem to be fruitful to uncover what students think both engagement and working mean and this might be achieved by interview or questionnaire, for example: ‘My definition of working when in mathematics classes is…’, ‘Students like me are engaged in mathematics when…’ or ‘An example of when I felt engaged in my mathematics learning was…’

Further information could also be gathered with a more nuanced exit slip or activity slip that is modified in response to emerging themes or extra information required. For example, in Lesson 9, a new exit slip prompt ‘because’ was added which seemed to elicit more useful information: I was most engaged when I was ‘making stop motion @ fractions’ because ‘it was fun’ (Ex-L9-8/17-Jenna). Also, further information might have been elicited with the following exit slip prompt: ‘I was working hardest in this lesson when…’.

**Cognitive engagement and student voice — and how to find out more**

Both the classroom teacher, Serena, and the researcher/presenter (me) thought the discourse on inverse proportionality applying to all fractions concepts was cognitively engaging for the students. However, the exit slip data from the students did not show any mention of that discussion. This poses several possibilities: (a) the students did not value the discussion; (b) they valued it but did not mention it; or (c) they valued it, but they did not register cognitive engagement as engagement.  Perhaps students only registered an activity as engaging if they produced something, they were active (they were ‘working’ or behaviourally engaged) or it was fun (emotionally engaging)? Again, more detailed exit slips or activity slips may uncover when students are cognitively engaged, for example: 'I was thinking hard when… because…'.

Similarly, the students were not directly asked about their cognitive engagement when asked to create digital animations linking fractions concepts and when using the gradient device and relating that to fractions. As well as directly canvassing cognitive engagement, it would be of further interest to explore if bringing students' attention to their cognitive engagement would improve students' valuing of it. Further research on cognitive engagement using a task design focus (see Ainley, Pratt & Hansen, 2006) seems to be warranted.

## 9.4 Theoretical Implications

In this sub-section, I discuss the implications of the definitions used in this study, which were derived from the works by many theorists, to suit the grainsize and often transitory duration of engagement or disaffection in learning activities. I also discuss the graphical depiction of the theoretical framework of the study and query whether further pathways, as suggested by the findings of this study, might be added to it.

### Conceptualising engagement in learning

The definition of engagement used in this study was drawn, influenced by and amalgamated from multiple sources (Attard, 2013; Boekaerts, 2016; Durksen et al., 2017; Eccles, 2016; Fredricks et al., 2004; Gettinger & Walter, 2012; Liem & Martin, 2012; Pekrun, 2006; Pintrich & De Groot, 1990; Sinatra et al., 2015; Skilling, Bobis, Martin, Anderson, & Way, 2016; Skinner & Pitzer, 2012; Taylor & Parsons, 2011). The definition used is as follows: 'Learning activity engagement is behaviour and mental processing directed towards achieving learning goals and is associated with enjoyment or interest'. This definition seemed appropriate for researching the learning activities context in this study, but it also brought into question how to define other behaviours found.

Clarifying the learning goal within the definition of the engagement, as suggested by Boekaerts (2016), seems to be important in illuminating the purpose of observed behaviours and reason for stated or observed emotions. That is, if the goal is to learn, then behaviours or mental processing directed towards that learning goal is engagement, as is enjoyment or interest expressed from those activities. Of the three 'classic' components of engagement, behavioural, affective and cognitive, it would appear that cognitive engagement is the least able to be conflated with another goal (like having fun or complying with conventions or the wishes of others) but it is the hardest to observe as it occurs within a person's mind with few overt indicators.

Crick (2012), for example, uses the term 'compliant engagement' to describe when an individual appears to be dutifully working towards a learning goal but does not seem interested in or committed to the learning. It would seem that with compliant engagement an individual holds the goal of compliance, not learning. In this study, the following were not able to be differentiated: (a) compliant engagement; (b) learning engagement with momentary frustration or boredom by an activity or pedagogical choice, but the student pushed through that to learn despite the hindrance; and (c) compliant engagement whereby enjoyment was expressed but for some other reason, not learning engagement. It is possible that, although best efforts were exercised, some compliance engagement was categorised as learning engagement and some momentary boredom or frustration was categorised as disaffection (lack of committed working towards a learning goal) and some disaffection was really disengagement (no engagement) or vice versa. It would seem that more nuanced data collection design and further research might elucidate the differences more clearly.

**Conceptualising disaffection and disengagement**

The defining of disaffection as the opposite of engagement (Skinner & Pitzer, 2012) led to the following working definition for this study: 'Disaffection is characterised by the lack of committed action or mental processing directed towards achieving learning goals and is associated with boredom, frustration or a lack of interest'. This definition also seemed both useful and yet problematic in this study. At times when students expressed boredom for an activity and did not seem to work diligently towards the activity or lessons aims, this definition could describe their behaviour as disaffected. However, there were noticed behaviours that did not seem to match this definition. How would behaviour of students be categorised of those who appeared to want to engage, but were seemingly stymied, distracted or influenced by, for example, the behaviours of peers? For instance, in Lesson 11, Jacob, who appeared mostly to engage in the activities of previous lessons, seemed influenced and distracted by his friend Hunter's apparent disaffection and perhaps acting out. Jacob was not focussed on the learning goals of the lesson, but was not seemingly presenting as apathetic, bored or frustrated either; rather he appeared distracted. His behaviour and focus seemed directed toward the goal of pleasing his friend. Perhaps, for most of the activities for this lesson, Jacob was disengaged rather than disaffected.

The definition used in this study for disengagement is as follows: 'Learning engagement disengagement is switching off from a learning activity with no action or mental processing directed towards achieving the learning goal and is feasibly associated with negative achievement emotions: boredom, anxiety, anger, shame and disappointment'. The lack of clarity about the emotions associated with the definition of disengagement here made it difficult to ascertain if some behaviours were categorisable as disengagement or not. Jacob's behaviour in Lesson 11, although not as disruptive as Hunter (apparently inveigling his friends in non-learning activities) or as disconnected as Nathan (drifting off to practise what looked like dance moves in class) seemed more understandable as disengagement (no effort or actions directed towards the learning goals) than disaffection. Jacob watched his friend, Hunter, in his exploits rather than do anything towards the learning goals, but he did not seem to exhibit ostensible negative emotions. It seemed that Jacob was just 'not engaged'. I was also unsure how to classify behaviour of students who wrote they were bored but, using deduction and video evidence for these anonymous responses, seemed more engaged than their self-rating would appear to indicate. It seems that further research on conceptualising the differences between, and working definitions of, disaffection and disengagement at the learning activity level are needed. Also, further research, perhaps pairing experience-sampling (see Goetz et al. 2014) with a 'because' prompt, may help uncover motivations for stating one level of engagement but exhibiting another.

## Graphical depiction of the theoretical framework

The graphical depiction of the theoretical framework for this study helped me in my analysis to make sense of the interconnection among three theories, self-determination theory, expectancy value theory and control value theory, and to visualise what appeared to be happening when describing the students' behaviour and responses. Please refer to Figure 9.1 (the visual depiction of the conceptual and theoretical framework that was used in this study and is reproduced here for convenience).

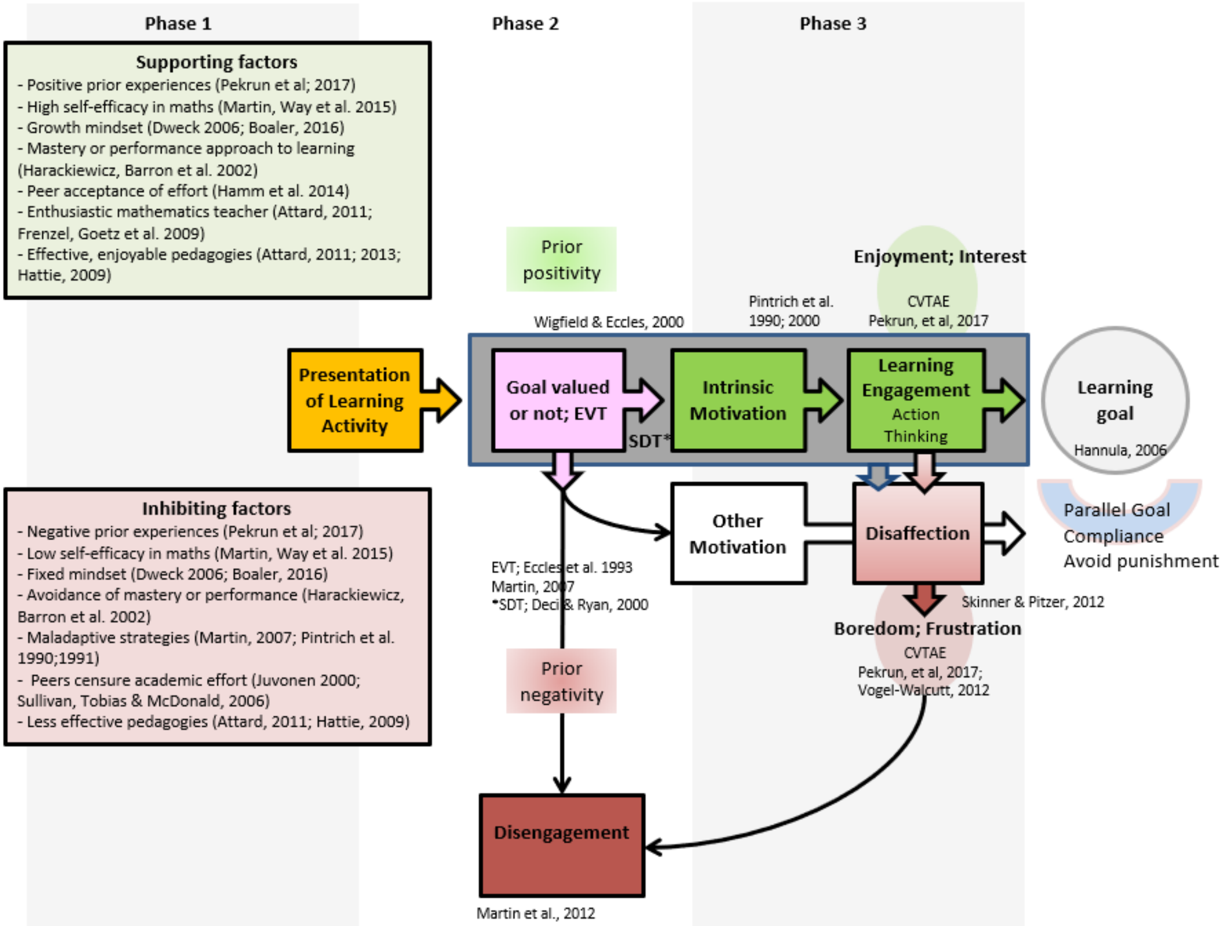



*Figure 9.1.* Conceptual and theoretical framework model used in this study for visualising learning activity engagement, disaffection and disengagement in relation to self-determination theory (SDT), expectancy value theory (EVT) and the control value theory of achievement emotions CVTAE).

The findings of this study suggested amendments to this framework (the modified diagram is presented in Figure 9.2): (a) an additional pathway from disaffection to compliance; (b) a new parallel reward goal; and (c) additional pathways after success or failure to achieve the learning goal. The theoretical model was changed to reflect that learners can go from disaffection to ‘other motivation’ and work towards a parallel, extrinsically motivated goal to the learning goal. Some students seemed to work on the tasks but also expressed frustration and boredom. For example, Isabella appeared bored in Lesson 9 when the activity was to make videos of equivalent fractions linking concrete representations of equivalent fractions (using commercial plastic fractions pieces) with the mathematical big idea that multiplying by one, expressed in fraction form (e.g., 3/3, 5/5 etc.), does not change the multiplicand’s value. An earlier group had left their workings, so the activity had inadvertently become pointlessly easy, however, with encouragement from Serena, her teacher, Isabella still did the activity, apparently showing compliance engagement. In this case, it seemed that Isabella was motivated to comply with the wishes of her teacher to complete the activity but did not have learning as her goal. Serena seemed to have created a warm and trusting relationship with her students. This new pathway is depicted as a backward arrow in Figure 9.2 and attempts to show that extrinsic motivation can draw a learner from disaffection to a parallel goal next to, but not the same as, the learning goal.

A further parallel goal for rewards was added to the framework in response to the finding that some students seemed to focus more on fun and amusement than the goal of learning. For example, one student (Qs-I-Anon) stated that learning about visualising fractions was ‘timewasting’ because ‘I'd rather do something fun like go-karting’. More research might uncover if having a focus on fun is widespread and whether the external rewards (Deci et al., 1999) and activity emotions of fun (see Attard, 2011a) and amusement are differentiated from and are more valued than the internal rewards of success and engagement emotions of interest and enjoyment. It is also possible that the conditions in this study evoked the need for fun and amusement. The parallel reward goal for fun and amusement, separate from a learning goal, is added to the framework and is depicted as a green-outlined blue crescent above the learning goal in Figure 9.2. Future research on the conceptualisation of parallel goals might contribute to further theorising about these proposed amendments.

An additional set of pathways, after a learning goal has or has not been achieved, seemed to be of value to describe some findings in this study, and these appear to be explained by extant theories and findings. Pekrun (2006) described with control value theory that after a learning goal is successfully achieved, the learner experiences positive emotions (pride and satisfaction). Pekrun et al. (2017) also found that positive achievement emotions help predict future achievement and vice versa. This post-success positive feedback loop affecting engagement is depicted in green in Figure 9.2. Conversely, Pekrun and team found that when unsuccessful, learners tend to experience disappointment, shame or hopelessness and these negative emotions tend to predict future failure and vice versa. This post-failure pathway leading to disengagement is depicted in brown in Figure 9.2. However, resilience, (Martin, 2013; Skinner & Pitzer, 2012) and high self-efficacy (Bandura, 1977; Bandura, 1997; Goetz, Cronjaeger, Frenzel, Ludtke, & Hall, 2010; Linnenbrink & Pintrich, 2003) helps learners re-engage after failure. This proposed re-engagement pathway is shown as a green upward sweep in Figure 9.2.

In this study, an example potentially showing success leading to further success was when Lissy worked on one frame of the digital animation one lesson and in subsequent lessons elected to work on further frames and indeed complete the animation. Presumedly, the satisfaction of the previous successful completion of one frame, and the learning gained or consolidated, led her to engage in the task again to and complete more frames.

This study did not generate specific information about students' actions and emotions stemming from failure to achieve a learning goal because the study was focussed on engagement, not academic or learning outcomes, but I draw on my researcher reflections to show what seems to be an example of resilience-driven re-engagement in a goal after failure. I had the goal to study learning activity engagement in a Year 8 class co-creating an e-learning module, but for much of the study the students did not report engagement, but rather boredom and disaffection. My researcher reflections show evidence of my despondency and disappointment. However, seemingly aligning with research on resilience (Martin, 2013; Skinner & Pitzer, 2012) and self-efficacy (Bandura, 1977; Bandura, 1997; Goetz et al., 2010; Linnenbrink & Pintrich, 2003), a new approach was devised (creating and using the gradient device) and I proceeded with plans to trial stop-motion animation, and this is perhaps evidence of re-engagement with a goal. Please see Figure 9.2 showing these proposed further pathways of the model regarding achievement or otherwise of a learning goal for an activity, which might be explored, interrogated and researched further in theorising about student activity engagement.

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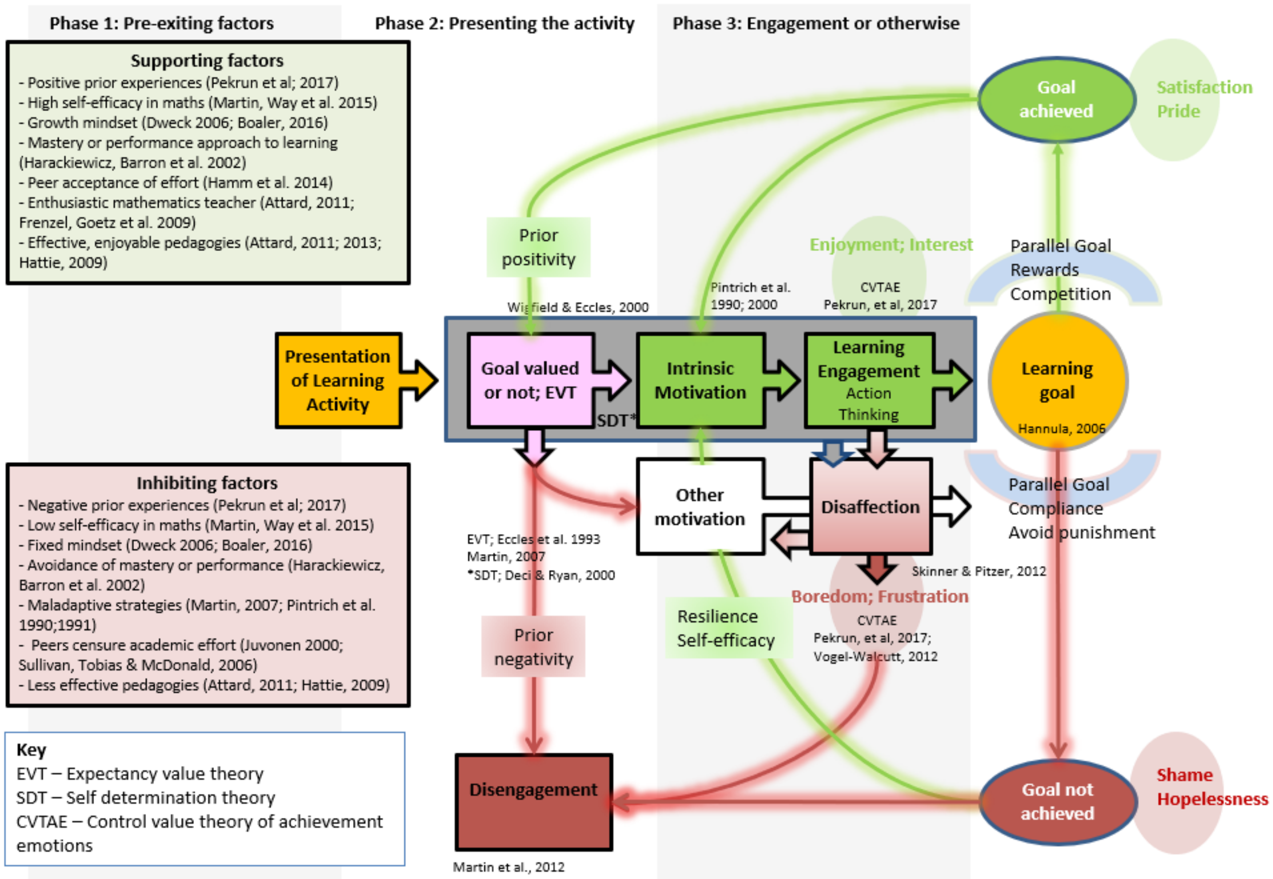


*Figure 9.2.* Proposed amended conceptualisation for depicting and explaining learning activity engagement, a pathway from disaffection to a parallel goal, extrinsic rewards goal and effects after goal achieved or not achieved

### 9.5 Limitations of the Study and Suggestions for Alternative Approaches

The aim of this exploratory case study was to pragmatically and theoretically investigate Year 8 students' engagement and disaffection, at the learning activity level, through the students' responses to the activities and conditions while they worked on an e-learning module for peers. Seven limitations were noted. The first limitation which seemed to affect the study's findings was that most of the students chose to give written responses that were anonymous. This meant that video analysis of the students' observed behaviour (including time spent on an activity) and cognitive engagement (including asking and answering relevant questions during mathematics discourse) could not be matched with their self-ratings of engagement in the exit slips or responses in the questionnaire. Providing students with the option of making anonymous responses in this study (to address the potential power differential between teacher and student) may have elicited more candid responses from them. Yet it may also have afforded an avenue for some students to express their perceptions more disparagingly or even to modify them (since the lack of consequences might have been an incentive for some students to inflate their expression of boredom). Future research might weigh the benefits of allowing student anonymity with that of allowing trackability between data sources.

A second limitation of this study was that the presenter and researcher were the same. This may have been more disruptive for the students and made it difficult for them to separate different sources of disaffection. Further research might be conducted whereby the classroom teacher teaches the lessons and a researcher observes them.

A third limitation of this study was that students' perceptions of their engagement was collected at intervals somewhat distally from the learning activities. The exit slips were administered at the end of lessons, in which multiple learning activities had occurred, and the questionnaires and focus group discussion were administered weeks and months, respectively, after the lesson sequence. Although distal reflection could be retained in further research, an additional data collection method could involve administering 'activity slips' after and perhaps even during each activity. A more elaborate and finely tuned strategy for research on activity-level engagement could include multiple recording devices to capture multiple student conversations and behaviours (e.g., Ing et al., 2015) or using real-time experience-sampling with personal digital assistants (e.g., Goetz et al, 2014).

A fourth limitation of this study was that, although planned to be a student-centred project, creating an e-learning module was not an idea which came from the students and this lack of ownership may confounded and diminished learning activity engagement. In further research, students might contribute to the design. That is, the researcher could pose the problem — lower secondary students can become disengaged from their studying of mathematics — and ask for suggestions, pose some possibilities and work with the students to set up a shared goal. The students might choose a range of mathematics activities as a lesson sequence, create animations and other digital material for YouTube, create an e-learning module for unknown peers or something else. Perhaps a shorter-term research study focussed on *in situ* learning activities might be of value too.

A fifth limitation of the study was that the three ‘classic’ components of engagement, behavioural, cognitive and affective engagement (Fredricks et al., 2004), were not differentiated or explicitly queried through the open-ended prompts in the exit slips or elsewhere. It is likely that more explicitly worded prompts may have elicited more detailed and focused responses from the students. The construct of cognitive engagement seems to be the most definitively related to learning activity engagement. Although some evidence, particularly on video, showed cognitive engagement, this was seldom expressed by the students in their responses.

A sixth limitation of the study was that the students were not specifically asked about their conceptualisation of engagement. Although their responses about when they were most engaged seemed to fit with dictionary and literature understandings of engagement, knowing what the students thought about engagement directly would have added to the study.

A final limitation of the study was that the instruments chosen could not differentiate what seemed to be boredom proneness (a within-individual tendency to experience multiple contexts as boring) from either acting out (due to psychological needs not being met) or the more negative boredom types (reactant and apathetic) as found by Goetz et al. (2014) or whether there might be a congruency between the etiology and manifestation of all three. Also, more detailed information was needed to explore if students were expressing boredom and lower engagement levels despite some ostensibly engaging experiences because they conflated tiredness with boredom, the negative experiences overwhelmed any engagement or the students wanted to maintain a boring narrative for social reasons (e.g., solidarity, anti-establishment push back, reactions against the researcher/presenter or as an outlet for a bit of rude fun with no disciplinary consequences).

## 9.6 Conclusion

The impetus for this study was widespread, persistent disengagement of lower secondary school students in mathematics which has robust, ongoing implications for the students themselves, and also for the nation and its future workforce. In this study, learning activity engagement was explored over a sequence of lessons, using case study methods, while a class of Year 8 students worked on co-creating an e-learning module on fractions for peers. As well as presentations with short activities, group problem solving and mathematics discourse, other activities offered were those more seldom included in Year 8 mathematics: stop-motion animation; digital learning object appraisal and using a gradient device to explore fractions and gradients. The data collected included exit slips, questionnaires, classroom videos, group and teacher interviews, students' animations and other student-produced artefacts and researcher journaling.

Although the students produced a game, four stop-motion animations and 37 videos, the planned e-learning module was not completed. Some situational impediments seemed to have contributed to this, but mainly researcher assumptions were exposed by the realities of the classroom.

Several apparent contributions to the literature are noted.  It was thought the students would enjoy teacher-like roles, like creating assessments and appraising content, but they primarily seemed to experience this as threatening or irrelevant and appeared to avoid roles involving judgement of or by known peers. This finding might help future researchers and teachers avoid inadvertently disaffecting lower secondary students by taking care to neither expose them to juvenile material nor ask them to judge materials for known peers' use nor create assessments for known peers nor present created work for known peers' assessment.

Differentiating of the source of the students' expressed boredom is thought to be a contribution to the literature and potential teacher practice. Unfortunately, boredom featured strongly in students' written responses. However, the richness and apparent candour of these responses enabled sorting of them by their apparent sources of boredom: (a) situational; (b) content-value-related; (c) pedagogical (too passive); (d) social (some students seemingly wanted to express boredom); and (e) within-individual (boredom proneness). A practical outcome was that some sources of expressed disaffection seemed addressable: (a) reduce teacher talking time and increase student active time; (b) avoid presenting early adolescent students with juvenile material and tasks involving judgement of or by known peers; (c) present challenging work with age-appropriate concepts; and (d) manage and plan for logging in problems and slow networked computers. Other situational hindrances, like the late Friday afternoon timeslot, were outside of my control, but were also deemed less impactful on engagement. Teachers might appreciate the development of information which considers classroom boredom, its sources and potential ways to address it.

Further research would be worthwhile to explore apparent boredom or disaffected behaviors which were to harder address: (a) how to help prevent students navigating away from planned activities to play unrelated games when online; (b) helping students who are predisposed to disliking computers; (c) managing mixed appreciation for learning topics (from finding them irrelevant to interesting); (d) expression of boredom beyond that ostensibly observed, perhaps for social effect; and (e) exploring the prevalence, etiology, repercussions and management of boredom proneness.

As well as reporting most engagement when ‘working’ (their definition unclear), the students seemingly liked the hands-on, creative activity of making stop-motion animations and appeared engaged when using the gradient device with a simple, variably sloped runnel and a marble. Although the students’ exit slips did not mention the device or the ensuing discussion, both the teacher and the researcher thought using this device helped elicit worthwhile mathematics discourse. There seems to be potential in further trialling the creation of stop-motion animation in lower secondary mathematics classrooms and in further developing and testing the gradient device. Exploration of students’ meaning of work and engagement seems warranted. Also, perhaps specific to this study, the students seldom mentioned cognitive engagement. More specific methods might uncover whether other lower secondary students do not seem to value cognitive effort and might need to be trained to recognise and value it.

Some methods used in the study might contribute to the literature. The exit slips were quick and inexpensive to administer and included both self-rated (SR) quantitative data and responses to open questions which allowed ranking by SR and creation of unique identifiers for anonymous responses. These might be useful in other studies involving anonymous participants over time. Using colour-coding to show, sort and see patterns of themes in the spreadsheet program Excel seemed to have merit. However, the exit slips could be developed to become ‘activity slips’ to hopefully elicit more detailed information about activities rather than the whole lesson, or more refined methods, like experience-sampling (see Goetz et al., 2104) would generate responses more proximal to the learning activity.

The working definitions used in this study, derived from the works by many theorists, were constructed to match the grainsize and duration of learning activity engagement and disaffection. Mostly, the working definitions appeared to be useful in this study. However, discerning learning activity engagement from compliant engagement was sometimes difficult and neither the working definitions for disaffection nor disengagement could describe non-engaged but non-disaffected behaviour. So, more research more seems to be required to conceptualise and define these terms at the learning activity level.

The theoretical model of engagement developed during and for this study helped me, and may help others, to understand the complex nature of engagement. Expectancy value theory (EVT), self-determination theory (SDT) and the control value theory of achievement emotions (CVTAE) formed the theoretical framework for this study, and their interrelationships and those involving engagement, motivation, compliant engagement, disaffection and disengagement, as informed by extant literature, were depicted visually in this model. The findings of this study suggested further pathways be added to the model: (a) rewards as an extra, extrinsically motivated parallel or other goal; (b) an avenue from disaffection through to compliant engagement; (c) a post-achievement positive feedback loop; and (d) a post-failure trajectory splitting between disengagement and re-engagement, the latter supported by self-efficacy and resilience. Further research could interrogate the proposed connections and test the whole model.

Attempting to construct a conceptualisation of learning activity engagement has helped me, and may help others, to understand its ostensible components and complexity — what precedes, supports and hinders it. Further research seems worthwhile on stop-motion animation and age-appropriate concrete manipulatives for lower secondary mathematics and what work these students find engaging. Those outcomes might help increase student engagement. A contribution of this study might be that teachers can be better equipped to identify sources of disaffection, address what is feasible, and take heart that some of the boredom expressed by early adolescents might be for social or personal reasons outside of their sphere of influence as teachers. This might be empowering for teachers.

> Growth occurs when individuals confront problems, struggle to master them, and through that struggle develop new aspects of their skills, capacities, views about life.
>
> *Attributed to Carl Rogers*

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*Appendix A*

Ethical Forms: Explanatory Statement, Consent and Student Assent Forms

MONASH University

## EXPLANATORY STATEMENT

**Year 8 Mathematics Students and their Parents**

**Project: Design based research on a novel intervention: Co-creation of an e-learning module on fractions by Year 8 students for peers**

**Dr Karina Wilkie**
Senior Lecturer, Mathematics Education
Faculty of Education
Phone: 9904 4227
email: karina.wilkie@monash.edu

**Ms Melinda Evans**
PhD Candidate
Faculty of Education

email: melinda.evans@monash.edu

You are invited to take part in this study. Please read this Explanatory Statement in full before deciding whether or not to participate in this research. If you would like further information regarding any aspect of this project, you are encouraged to contact the researchers via the phone numbers or email addresses listed above.

**What does the research involve?**

The aim of this study is to investigate a new way of learning maths — by a class of Year 8 students moving into peer-teaching roles and creating an e-learning module on fractions for peers to use. This has two purposes. Firstly, we want to see if this helps you, the participants creating the e-module, to learn the content more deeply and be more engaged with your maths learning. Within that, we want to know which activities that you participate in help you the most and least in your learning and being engaged. Secondly, we want to know if it helps other Year 8 students, who use the finished e-module, learn the content and be engaged with it.

You and your classmates will be asked to work on this project for one mathematics lesson per week for one term, plus a little extra time to obtain feedback from other Year 8 students on their learning experience with the finished module. Your participation will involve creating or selecting online resources to teach other Year 8 students about fractions. So, for example, for several of the weeks you might be in a group working on a video showing different fractions concepts and another group might be working on making a multiple-choice quiz.

Your participation in the research will involve:

- Doing an assessment on fractions
- Filling in an exit slip at the end of each lesson
- Doing an interview with Melinda
- Joining in with group discussions
    - These interviews and discussions will be audio-recorded for research purposes and de-identified (this means Melinda will write up what is said, but will either use made-up names or include what people say in grouped themes without names, so that others cannot identify who said what)
- Allowing Melinda to collect and analyse the module that your class produces
- Being observed by Melinda
- Being videoed during the lessons
    - This is so we can see if the activities are engaging or not
    - Melinda will analyse the video to see how engaged students are at set points in the lesson. You will have the chance to contribute to the assessment made. (Formally, this last process is called member checking). This research will not be available for school use and will not have anyone's name attached to the videos ever.
    - We also ask for extra permission if a video you are in could be used at a conference (not published anywhere else at all, ever). This is a new way of teaching so teachers and researchers might appreciate seeing the participants in action.

**Why were you chosen for this research?**

You have been chosen for this research because you are a Year 8 mathematics student at this school and your teacher has agreed to be part of this research.

**Consenting to participate in the project and withdrawing from the research**

If, once you have read this information, you are willing to participate, please sign the accompanying consent form and return it to your teacher. Your parents' or guardians' permission is required too before you can participate.

Your participation in this research is completely voluntary. You can withdraw at any time. You can opt out of any of the research components at any time. Should you wish to withdraw at any stage, or to withdraw any unprocessed data at any stage, you are able to do so by contacting either Melinda or Karina.

If you choose not to participate, you will be given work to go on with that covers the same topics that will be studied by those participating in the research. Your teacher will still be available to help you with your studies to a similar degree as you would experience normally.

**Possible benefits and risks to participants**

A possible benefit of this study is that together we will develop a way of teaching which is engaging and improves learning for students. The type of research used for this study, design-based research, includes the inputs from the participants so it is not research done on students and teachers, but with them. So, this study has the potential to give students a voice as to how they would like to learn.

The method itself could eventually be a tool to help teachers to assist their students who present with mathematics learning gaps to firm up their understandings in strategic topics and to engage in a project as a class.

Another benefit is that hopefully participants will have a better understanding of fractions. Fractions is topic which many people have difficulty with, and it is a key that unlocks subsequent topics like percentages, rates of change, and eventually calculus.

The online module in fractions that participants will be making with classmates could be a tool which your school can use for current and upcoming students to help them efficiently understand the often-tricky topic of fractions. Since the module will be created at your school and for your school it is likely to be of benefit to other local students of your school who will not only understand the concepts of but the culture behind what you have produced.

Later, if your school chooses, the module could be uploaded to a site for other schools to use.

It is not foreseeable that completing the questionnaire will give rise to any appreciable level of inconvenience or risk of harm to participants.

**Confidentiality**

None of the data collected will use participants' real names — a pseudonym or no name at all will be used if a person's response is quoted in the research. Only illustrative comments which relate directly to the research would be used and none will be used which refers to any person's relationships, relative performance or sensitive or potentially sensitive data. However, the majority of the reported information will be aggregate de-identified data. This means that responses will be pooled, and no-one's responses will be linked to any individual. For example, 'Seventy five percent of the students responded that…' or 'A theme which emerged from the interviews was…'

Unless specific written permission is given by all people captured in particular video footage for live use at presentations, video footage will only be accessed by the named researchers on this document, Melinda Evans and Dr Karina Wilkie, for research purposes. Neither the school's name or details nor any participant's name or details will be revealed at live presentations or in any publications. Where a person who has not given permission for their image/s to be used for presentations has been captured in video footage that is of note for educative purposes, that person's image will be de-identified (pixelated or blurred) post-production if they are in the background. The clip will simply not be used if the person who has not given permission for their image/s to be used for presentations has been captured in video footage is speaking or moving identifiably or in the foreground. Video footage, of any nature, will not ever be published or released for viewing by the general public, including the school.

The data will be presented at a conference, included in a PhD thesis and may be reported in one or more journal articles.

**Storage of data**

The written-on-paper data of this project will be stored in a locked filing cabinet and will be accessible by the PhD candidate conducting the research, Melinda Evans, and her supervisors, Dr Karina Wilkie and Dr Marc Pruyn. The electronic data and analyses of this project will initially be collected on Melinda's personal laptop computer and then transferred to a secure Monash University drive with access by Melinda, Karina or Marc only. Only de-identified data will remain on Melinda's laptop for as long as she is associated with Monash University.

**Use of data for other purposes**

The data may be used in a conference to educate researchers and teachers about the project. Also, some data might be used in teaching student teachers about the project and its findings. Only aggregate de-identified data may be used for these purposes where ethics approval has been granted.

**Results**

The results will be made available to the public on publication of Melinda's PhD thesis. The school will have Melinda's email address to obtain a copy once it is completed at the end of 2018.

**Complaints**

Should you have any concerns or complaints about the conduct of the project, you are welcome to contact the Executive Officer, Monash University Human Research Ethics (MUHREC):

Executive Officer
Monash University Human Research Ethics Committee (MUHREC)
Room 111, Chancellery Building E,
24 Sports Walk, Clayton Campus
Research Office
Monash University VIC 3800

Tel: +61 3 9905 2052 Email: muhrec@monash.edu Fax: +61 3 9905 3831

**Thank you,**

**Dr Karina Wilkie** **Ms Melinda Evans**

*Appendix A cont.*

MONASH University

# CONSENT FORM

**Parents or Guardians of Year 8 Students**

**Project: 'Design based research on a novel intervention: Co-creation of an e-learning module on fractions by Year 8 students for peers'**

**Chief Investigator:** **Dr Karina Wilkie**
**Researcher:** **Ms Melinda Evans (PhD candidate)**

My child has been asked to join in this Monash University study. I have read the letter that explained everything about this study, and I have had a chance to ask questions about it. I understand what this research project is about and agree for my child to join in.

I understand that for my child being in this study is both my choice and that of my child. Either one of us can change our minds and choose to not participate in this study at any stage. I know that if I have any questions, I can ask my child's teacher or the researcher at any time.

I understand that I can agree to some, all or none of the items below.

| I agree for my child to: | Yes | No |
|---|---|---|
| Do maths assessments | ☐ | ☐ |
| Join in with group discussions about the work which are audio-recorded | ☐ | ☐ |
| Fill in exit slip surveys about the research and activities | ☐ | ☐ |
| Be observed by the researcher | ☐ | ☐ |
| Do an interview with the researcher | ☐ | ☐ |
| Have the interview audio recorded | ☐ | ☐ |
| Be videoed in class for research purposes only | ☐ | ☐ |
| Being videoed while tutoring or presenting by classmates for school use | ☐ | ☐ |
| Show the class's finished module to another student and get feedback on it | ☐ | ☐ |
| I agree to: | | |
| Have an excerpt or still of a video my child is in used during live presentations, not published | ☐ | ☐ |

Child's name ______________________ Date ______________

Parent/Guardian name/s ______________________

Signature/s ______________________

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*Appendix A cont.*

## ASSENT FORM

**Year 8 Students**

**Project: 'Design based research on a novel intervention: Co-creation of an e-learning module on fractions by Year 8 students for peers'**

**Chief Investigator:** **Dr Karina Wilkie**
**Researcher:** **Ms Melinda Evans (PhD candidate)**

I have been asked to join in this Monash University study. The letter that explained everything about this study has been read to me and I have had a chance to ask questions about it. I understand what this research project is about and would like to join in.

I understand that being in this study is my choice and that I can change my mind and choose to not be part of this study any time I like and that no one will be angry with me if I change my mind. I know that if I have any questions, I can ask my teacher and parents or the researcher at any time.

I understand that I can agree to some, all or none of the items below.

| I agree to: | Yes | No |
|---|---|---|
| Join in with group discussions | ☐ | ☐ |
| Have group discussions audio recorded for research purposes only | ☐ | ☐ |
| Let my teacher talk to the researcher about my activities in class | ☐ | ☐ |
| Fill in exit slip surveys about the research and activities | ☐ | ☐ |
| Be observed by the researcher | ☐ | ☐ |
| Do an interview with the researcher | ☐ | ☐ |
| Have my interview audio recorded | ☐ | ☐ |
| Be videoed in class, with videos used only for research purposes | ☐ | ☐ |
| Have an excerpt or still of a video I am in used during live presentations, not published | ☐ | ☐ |
| Show our finished module to a student outside of our class and get feedback on it from them | ☐ | ☐ |

Name ______________________________ Date ______________

*Appendix B*

Exit Slips Administered to Students at the End of a Lesson

(a) Original exit slip in A5 size

*Note.* The prompt 'I had difficulty with…' was dropped from reporting to conserve space as it was mostly left blank by the students or the response 'Nothing' was entered

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**Exit Slip** **Date** ____________ **Name** (optional) ____________________

**1. I felt engaged in today's session** (please circle)

| 1 ◯ | 2 ◯ | 3 ◯ | 4 ◯ | 5 ◯ |
|---|---|---|---|---|
| Not at all | A little | About half the time | A lot of the time | All or nearly all of the time |

I was most engaged when I was…

I was least engaged when…

**2. I learnt well in today's session** (please circle)

| 1 ◯ | 2 ◯ | 3 ◯ | 4 ◯ | 5 ◯ |
|---|---|---|---|---|
| Strongly disagree | Disagree | Not sure or somewhat | Agree | Strongly agree |

Today I learnt about…

It helped me learn when…

I had difficulty with…

It interfered with my learning today when…

*Appendix B cont.*

(b) Modified exit slip in A5 size

*Note.* Included the extra prompt 'because…' The prompt 'I had difficulty with…' was deleted

MONASH University

**Exit Slip** **Date** ____________ **Name** (optional) ____________________

**1. I felt engaged in today's session** (please circle)

| 1 ◯ | 2 ◯ | 3 ◯ | 4 ◯ | 5 ◯ |
|---|---|---|---|---|
| Not at all | A little | About half the time | A lot of the time | All or nearly all of the time |

I was most engaged when I was…

because…

I was least engaged when…

because…

**2. I learnt well in today's session** (please circle)

| 1 ◯ | 2 ◯ | 3 ◯ | 4 ◯ | 5 ◯ |
|---|---|---|---|---|
| Strongly disagree | Disagree | Not sure or somewhat | Agree | Strongly agree |

Today I learnt about…

It helped me learn when…

It interfered with my learning today when…

*Appendix C*

Questionnaire on Activities from Lessons 2 to 8

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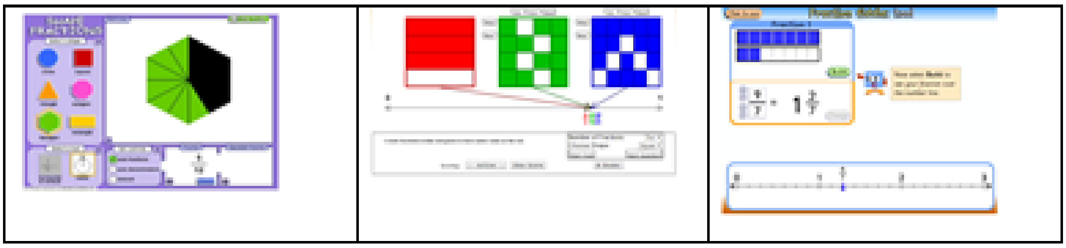
## Questionnaire for Year 8 Students to give feedback on e-learning module creation activities

For each of the following activities for our project please note what you thought about them.

1. You were asked to assess digital learning objects in Scootle for **other Year 8s**



*I found looking at Scootle learning objects for Year 8s* ............................................

*because* ..........................................................................................................

..........................................................................................................................

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2. What if you assessed learning objects in Scootle for ***Year 5 or 6s*** to use?

*If I was asked to assess learning objects in Scootle for Year 5 or 6 students,*

*I would find this* ..............................................................................................

*because*...........................................................................................................

..........................................................................................................................

..........................................................................................................................

..........................................................................................................................

..........................................................................................................................

3. *The digital learning objects that I would find effective for my own learning of fractions would……………………………………………………………………………………..*

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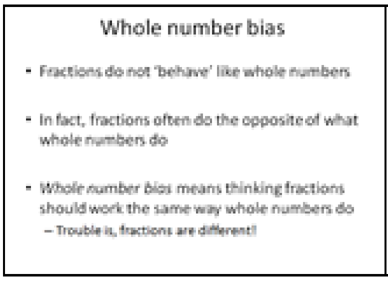
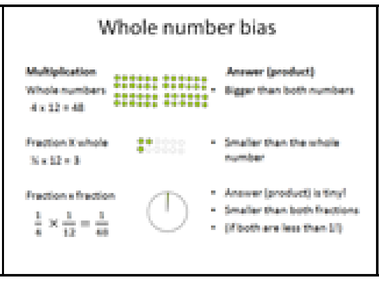
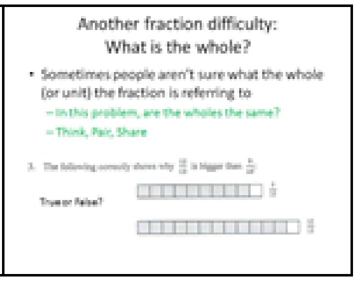
4. We looked at specific difficulties people have with fractions.




*I found learning about difficulties people have with learning fractions……………….*

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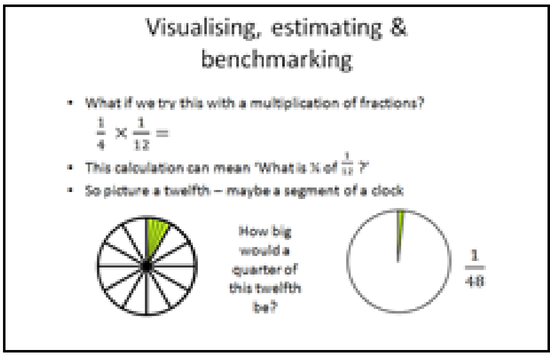
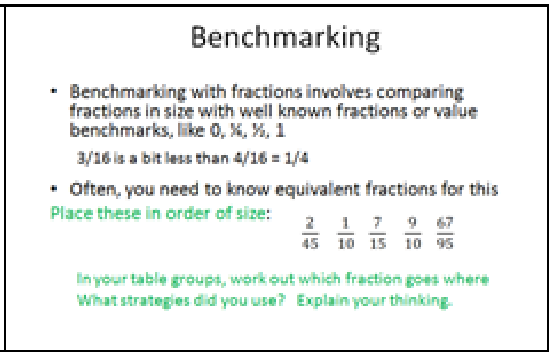
5. We looked at visualising and benchmarking with fractions.




*I found learning about the visualising of and benchmarking with fractions .........*

*.......................................................... because...............................................................*

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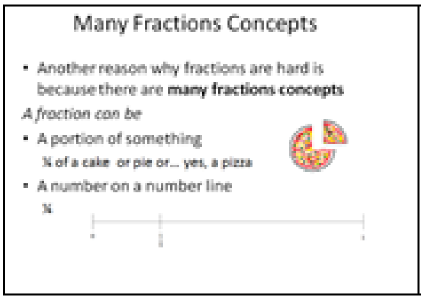
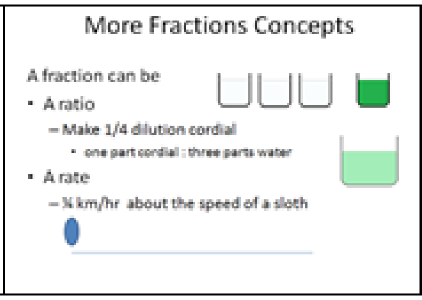
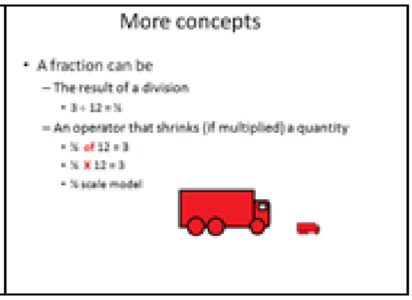
6. We looked at the different concepts of fractions.




*I found learning about the different concepts of fractions .....................................*

*.......................................................... because...............................................................*

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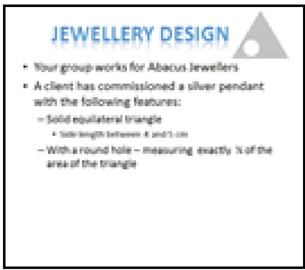
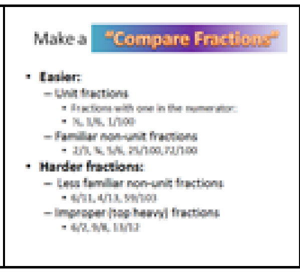
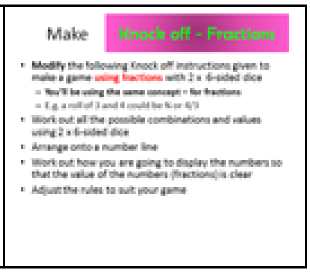
7. Please now think about working in groups on different problems involving fractions.








*I found working in groups on different problems involving fractions……………………*

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*This activity could be improved by ……………………………………………………………………………*

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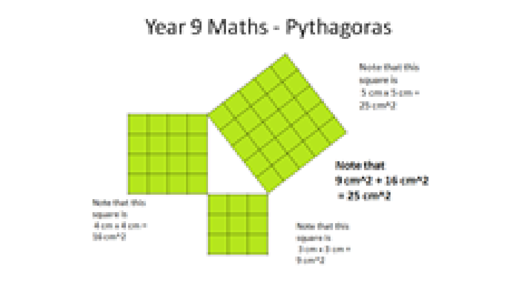
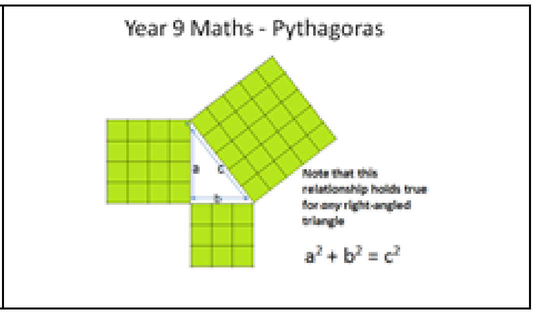
8. Please now think about learning the harder Year 9 concept of Pythagoras




*I found learning about Pythagoras theorem*…………………………………………………………

*because*……………………………………………………………………………………………………

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*If I had the opportunity to learn about other harder mathematics concepts,*

*I would*………………………………………………………………………………………………………

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What other concepts have you heard about, if any, which you would like to learn about?

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***Thank you for completing this questionnaire***

*Appendix D*

Focus Group Discussion Questions

1. **What suggestions do you have for what activities to include** if this project ran again with another group similar to yourselves?
2. **Think back to the project, tell me what you thought about making stop-motion animations in class.**
    a. What suggestions would you have if this project ran with another class about stop-motion animations?
3. **Think back to the project, tell me what you thought about making videos in class**
    a. What suggestions would you have if this project ran with another class about making videos?
4. **What do you think about using computers in class?**
    a. What about in other classes, like English, for example?
5. What do you **now understand about fractions from participating in the project?**
6. What suggestions do you have for **what fractions concepts to include** if the project ran again with another group similar to yourselves?
7. **What if** this project ran again with another group similar to yourselves, and the **class was just given one concept to work on at a time**, like "as the denominator increases, the value of the fraction decreases"
    a. **How might students like to work**? Prompt if needed:
        i. Individually, in small groups, free range choice, be given a choice of projects etc
    b. **What ways** might they like to **show each concept**
    c. **How engaging might that be for them?**
8. If this project was to run again with another group similar to yourselves, **how might they feel if their finished work was going to be shown to other Year 8s**? Year 8st the same school? Year 5s?
    a. Who should the target group be?
    b. What if it was just kept 'in house'?

Appendix E

Focus Group Discussion Transcript

**Focus Group Discussion/Interview — 26th October 2017**

Not everyone in the class wanted to participate in the focus group discussion, so they were on the outside of the group doing mathematics work while the focus group remained in the classroom clustered around four small tables pushed together. Audio recording devices were placed on the tables. Researcher made notes. There were eight student participants: Lissy, Siobhan, Toby, Jacob, Zach, Kate, Cynthia and Nathan; and the interviewer (IVR), Melinda Evans.

*(Event descriptions and time stamps are in brackets and in italics.)*

IVR If you have decided not to join us for now, and you hear something — and you think, 'I wouldn't mind joining in. I've got something to say about that', you're welcome to join in.

I've got your consent to begin, is that right? I'm assuming that if you're sitting here, I have your consent to participate and be recorded.

Kate Are we able to sit here but not have to say…

IVR Absolutely. Absolutely, but everyone will be invited to say something if they want. Alright, the idea is that one person speaks at a time and there's no right or wrong answers. And we should expect different points of view. We don't need to have a consensus here. Everyone is invited to speak. And as I said earlier, not everyone has to answer every question. Alright? *(1:37)*

Think back to the project and please say what you thought about making stop-motion animations in class?

Toby It was pretty cool.

IVR OK, can you elaborate on that and say why it was good?

Toby Like, it was different to what we normally do in other classes

IVR OK

Toby And in maths classes where we just do questions, wherever she is, (referring to the class teacher and looking around), hi there, and just do bookwork. It was something different. It was good. *(2:07)*

IVR OK. Would anyone else like to say anything about doing stop motion animations? Anybody think that it wasn't what you wanted to do?

*(Nothing coherent or relevant is said. A respondent says 'Why?' loudly then again in a mock mysterious whisper, then apologises.)*

IVR Do you think other Year 8s would like to do stop-motion animation?

Toby More than likely… I'm the only one saying anything. *(2:39)*

IVR It's hard to start and get going and you've got other people around. Normally you'd have…

*(Toby says something incomprehensible — something about others being too quiet or maybe others not thinking they are smart enough?)*

IVR Everyone's smart in different ways.

Lissy, you were involved in making a stop-motion animation on the computer showing that increasing the denominator decreased the value of the fraction. Is there anything you would like to say about that? *(2:54)*

Lissy Ar… It helped me understand fractions.

IVR OK. So, working on that helped you understand fractions. OK. So, this feels a bit awkward to begin with, but if you just say something it might help you to get going.

What do you think about making videos in class? *(3:41)*

Cynthia I didn't do it.

IVR You didn't do much of that? That's OK.

Lissy It's more fun that actually writing stuff down.

IVR So making videos is more fun than writing things down on paper?

Toby Yeah. And not having to do bookwork. *(4:09)*

IVR Perhaps we'll come back to that one then and move on to something which… No, I won't prejudge that one. What can you tell me about choosing objects, learning objects, in Scootle?

Kate It didn't work for me.

IVR Good! Well, not good that it didn't work.

Toby Wait. Are we talking about things on the computer?

IVR Yes

Toby Yeah. I couldn't log in after like…

IVR You couldn't log in?

Nathan Yeah, I forgot my password.

IVR Yep. Kate, what would you like to say about why it didn't work for you?

Kate I couldn't log in or anything. It didn't…

Toby It disliked me *(something else indecipherable).*

*(laughter)*

IVR I'd have to agree with you. That wouldn't work. What can you say about using computers in class in general?

Toby It's better than writing. You can just type in like that *(motioning hands typing).* You can just press it *(motioning writing slowly and showing the expression of being tired).*

Kate They never work for me.

Toby Maybe *(to Kate)* it's because you have auburn hair? *(a bit of laughter)*

IVR Can you expand on that, Kate?

Kate Nah, they always stuff up.

IVR OK. Does anyone else have that same experience?... *(waiting for a few moments)* No?

If you were walking into a class and you were told that, 'Today, we're going to being working on computers,' what would you feel? What would you think?

Toby Yay. We get to listen to music. *(6:25)*

IVR *(laughs)*

Kate *(whispers)* I'd feel like walking back out of the class *(only heard on playback).*

IVR Sorry, Kate, I missed that.

Kate Nah, it's all good.

IVR OK. Zach, I've haven't heard from you yet. What do you think about using computers in class? … *(shakes head*) No? You don't want to comment on that yet? OK.

Cynthia Yeah. They're alright.

Siobhan *(whispers)* They're faster than writing.

Cynthia Yeah, they're faster than writing.

IVR OK, faster than writing. Thank you.

Nathan *(whispers)* Copycat

Lissy Less mistakes than when you're writing.

IVR OK, good. We might come back to that later. What about in other classes, like in English? So, compare using a computer in maths to using a computer in English?... Can you say what the difference is there?... *(long pause)* … Someone should make a cricket sound… OK, we'll move on then.

What suggestions do you have for what activities to include if this project was to run again with another group similar to yourselves? … What activities would you want? For example, we've had the Scootle one, looking at learning objects, and thought, Nup, that didn't work, so what things did work? If there was another Year 8 what would you recommend would be included in a project like this for them?

Kate Mathletics

IVR Matheletics? OK.

Toby Food rewards afterwards

IVR Food rewards? OK. *(laughs)* Yep. So, Kate you were talking about having… you'd like there to be games if you are going to be using the computers?

Toby Yes

Kate Make a competition

IVR OK. Competitions

Kate Make a game where you can compete against other kids.

IVR OK. What do other people think about competition and Mathletics in maths?

Kate We did it in primary school

Toby Oh, Mathletics is fun

Daniel Mathletics is good as

IVR Ah, thanks, Daniel. Mathletics is good as. Yeah… *(meaning go on) …* Zach, what do you think about Mathletics?

Zach It was a good program

IVR It was a good program. OK. So, this was about fractions which starts in primary school and goes all the way through, in maths learning, all the way through to university and on into life and into work life. So, it starts and builds and go keep building it up.

If you had to have this program again, and obviously you don't because this is the last session for you, and you had to have one topic and you were making things for that topic, what things would you have in it… You could say that this whole thing didn't particularly work, and that's fine too.

Lissy Working on the PowerPoint would be good. *(9:47)*

IVR OK, so working on the PowerPoint *(meaning making a digital animation using PowerPoint)* would be something to include in that.

Lissy It's probably the easiest to understand

IVR OK! One of the times I was giving lectures of information. Would you have that?

Toby Hmm. No. They were boring

IVR *(laughs)* No. Fair enough. So, what things would you have? So far, we've got a PowerPoint animation and that was good. You learnt something from that, and it was worthwhile. We spoke about stop-motion animation before. Would you have that in it?

Toby Add in some memes or something

IVR I don't know what that means

Toby Oh

Daniel Look it up

Toby Yeah, look it up. It's hard to… Just look it up

IVR OK, alright. So, stop-motion animation? Yes, no, maybe?

Toby Stop motion, yeah. *(10:43)*

IVR Stop-motion we'll put in, yeah? OK. Making videos — we'll put in?

Toby Hmm

IVR Making videos — not sure? *(11:00)*

What do you now understand about fractions from participating in the project?...

Can you think of any 'Aha' moments in the project?

Lissy How it relates to gradients

IVR OK, so how it relates to gradients. Good. Can you expand on that? Or think of anything else that made you think 'Oh, I get that now'?

Lissy Put the parts of a whole circle on top of each other to see how many fit into…

*(In the study, this seems to be referring to showing equivalent fractions by placing commercially made sector fraction pieces on top of each other; e.g. 3 x 1/12 fit onto ¼. The students were required to make a video in groups showing equivalent fractions in*

*two ways — explicitly linking the concrete with the more abstract mathematics — showing that the size of the fraction is not altered by multiplying it by values equivalent to one; e.g. ¼ x 3/3 = 3/12.)*

IVR OK, so manipulating those bits. Is there anything that anybody else thought, oh OK, I didn't know about Pythagoras or… how you'd go about making a course or…

Jacob No

IVR No? OK. So, what suggestions do you have for what fractions concepts to include in the project ran again with another group similar to yourselves? … So maybe relating fractions to gradients because… Well, Lissy, what was it about that that you went, 'Mm, got it'?

Lissy Um, as you moved… each place where you put the stick to hold the ramp up had a number and you could figure out the fraction from how it was set up, and it would be steeper depending on how fast the marble would be rolling down.

IVR Would you include that again? So, can I put that to the group? Where we had the little marble and it was going down the slope and you saw that…

Toby Oh that was fun. It was entertaining.

IVR OK. So that is something you'd recommend we could do with other Year 8s?

Toby Yeah.

IVR OK, what about where we were looking at fractions and speed, and we had 10 m and you had to walk it slow or you had to walk it fast

Toby We didn't do that, the girls did that.

IVR Ye...es. We did that once as a whole class.

Toby Oh really?

*(Kate left the group and the flow was lost momentarily)*

IVR Were there any fractions concepts that we covered, and you thought, 'Look, I've got this already. I don't need to go over that' … Too hard to answer?

Toby Go Zach. You were doing all those hard fractions and triangles and stuff…

Zach Er

IVR I'm interested in what you have to say

Toby Those triangles things pissed you off?

Zach A little bit

IVR That's OK. It's about the project and making the project better. So, the more things you say, even if they're negative and against it, the better, so we change things for the next group. It's better for them. It may be that it never happens again. If you think, 'Nah, I don't particularly like that' — That's fine as well.

So, you were intimating there, Zach, that there was something you didn't quite like? *(no answer)* ... You want me to come back to some other time? That's OK.

So, if this project were to run again with another group similar to yourselves, how might we set it up? Let's say you would be working on one concept at a time, say as the denominator gets bigger the value of the fraction gets smaller, and you could show that any way you like — you were given, video cameras stop-motion equipment — anything you like. How would you want to work? Premade groups, your own groups, in pairs…?

Toby Premade groups might be better. If you just put, like, friends together, the girls with the girls and the boys with the boys, like, they wouldn't get as much work done.

IVR So premade groups would probably work better?

Toby Yeah

IVR Does someone think differently? Would you prefer to make your own groups?... *(no answers)* Or work by yourself or in pairs?... This is your chance to give feedback about this… To make it better for the next group — if it happens again.

Lissy I think that maybe have premade groups but give them the option so if they want to work by themselves, they can.

IVR OK, thank you!

If this project were to be run with another group similar to yourselves, how might they feel if their finished work were to be shown to other Year 8s?

*(No verbal responses — but one student in particular, Zach, is shaking his head)*

No! *(in summation)* At this point, Zach is shaking his head. So, you don't want to show it to other Year 8s? Can we just go around — and if you feel like it — have a comment about that? So, imagine you've made a project and you're going to show it to other Year 8s, how do you feel about that?

Toby I wouldn't care

IVR You wouldn't care?

Jacob I wouldn't mind

Toby But wait…

IVR Sorry, just one person at a time, please. I really want to hear what you have to say.

Jacob I wouldn't mind that much

IVR You wouldn't mind?

Toby Would your names be shown on it?

IVR No. Not necessarily. No.

Toby I wouldn't care then.

IVR What if it was to Year 8s at the same school? Would that make a difference? Yes, no, maybe…

Toby Probably not at the same school

IVR OK, So, it would be OK with anonymous other Year 8s? Yes? *(looking around the circle — seeing nods of agreement)*

OK, so what about when it was posed that you make the project for Year 5s. Was that the right move? What would you like to say about that?

Toby Maybe Year 5s should be doing it for Year 5s

IVR OK

Toby Or, Year 6s — something closer

IVR So Year 8s make something for Year 8s *(looking around the circle — seeing nods of agreement)* OK, good, seeing nods of approval here. And Year 5s make something for Year 5s. Yes? *(more nods)*

If you can, can you tell me how you felt when it was posed to you that you'd be making this for Year 5s?

Lissy We had to, like, think of what Year 5s do, and I couldn't really remember

IVR OK, good, thank you, so you could really remember what it was to be in Year 5. Anything else you'd like to say about doing the project for Year 5s? How did it impact you? How did you feel? *(no answers)*

Is there something we should have talked about, but haven't yet? You are Year 8 advisers on the project. I can't know what you think about it. So, you have to tell me. And it's about the project, not about me, or anything else. It doesn't matter what you say; what matters is that your opinion is heard. What else would you like to say about the project?

Siobhan It was a bit repetitive. We do the same thing, then the bell would go and next time we'd do the exact same thing again. But we'd already done it the first time.

IVR Thank you. OK. So how did other people feel about it being a bit repetitive?

Toby I didn't really mind doing the same stuff. It was just playing *(bit indistinct)* and doing it again

IVR OK. Nathan, you looked like you were on the verge or saying something

Toby He just wants to go home

IVR Jacob, did you want to say something?

Jacob Not really

*IVR Thanks participants and they break to enjoy a party of chocolates, lollies and chips*

*Appendix F*

Groupwork Problems, Some Student Solutions and Student-Generated Animations

**Groupwork Problems**

With the students not wanting to create multiple choice questions for the e-learning module, the project was changed, for those lessons, to pose questions instead with worked solutions by the students and make elements for games. Referring to Figure F1, the students were divided into four groups and each given a problem involving fractions to solve within a hypothetical or real-life context:

Group 1. Work out a quarter of an equilateral triangle's area and then work out what the dimensions of circle that resultant area would be for a piece of jewellery

Group 2. For a tattoo design, interrogate whether an equilateral triangle, enclosed within a circle touching each vertex, will be exactly divided into quarters by the circle's horizontal and vertical radial lines. Extra Year 10 level challenge: justify your decision mathematically

Group 3. Make three groups of fractions comparison pairs, easier, medium and harder, for uploading to the competitive game feature within the e-learning hosting learning management system (LMS)

Group 4. Make a downloadable game based on all 36 fraction combinations possible with two 6-sided dice (e.g., $\frac{1}{1}, \frac{1}{2}, \frac{1}{3} \ldots \frac{3}{1}, \frac{3}{2}, \frac{3}{3}, \frac{3}{4}$ etc.) and finding equivalent fractions.

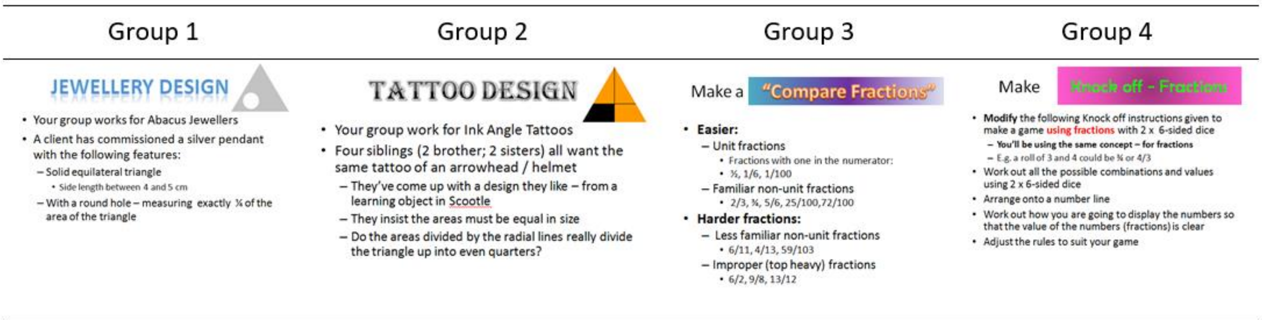



*Figure F1*. Presentations of Each of Four Groups' Problems to Solve or Activities to Help Produce

**Some Student Solutions to Groupwork Problems**

Students in Group 1, Cynthia, Kate, Isabella and Jenna, worked out the area of equilateral triangles using graph paper and counting squares. Referring to Figure F.2, this first strategy was aimed at a level for Year 5 end-users to understand.

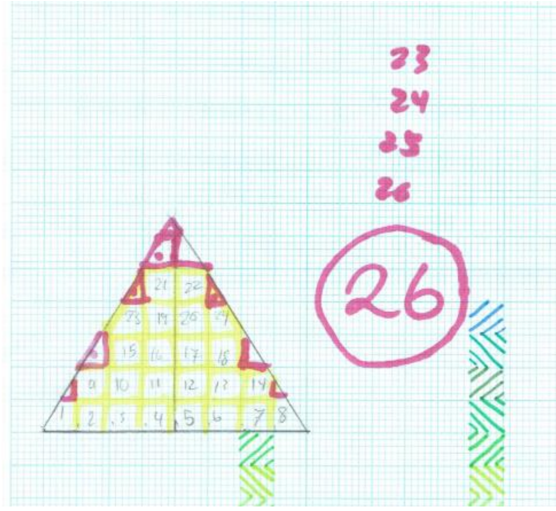



*Figure F.2.* Students' representative solution to finding the area of a quarter of an equilateral triangle in a manner suitable for Year 5 students to understand.

Referring to Figure F.3, with some guidance by their teacher, Serena, students worked out the radius of a circle one quarter the area of an equilateral triangle of sides 4 cm using the equation for the area of a triangle, Pythagoras theorem and the formula for the area of a circle.

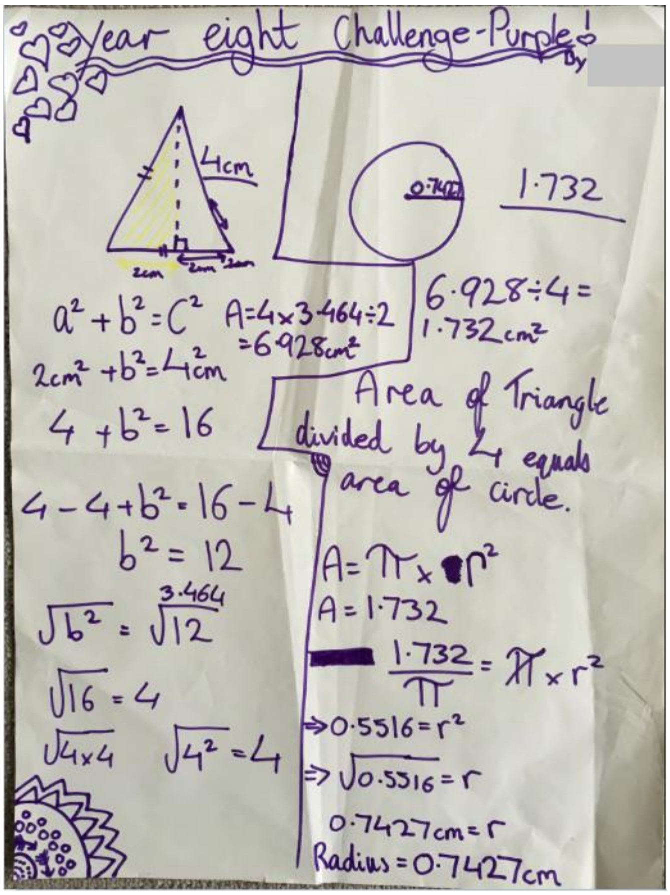



*Figure F.3.* Workings by Cynthia and Kate on the problem to find the dimensions of a circle exactly one quarter of an equilateral triangle with sides of 4 cm (real names obscured).

In Group 2, Toby, Ethan, Nicole and Sally made short videos (please refer to Figure F.4 and Figure F.5 for stills of these videos) to demonstrate finding a quarter of an equilateral triangle with logic and paper folding. Zach worked on finding a mathematical solution (please refer to Figure F.6 for Zach's mathematical workings on finding a quarter of a triangle).

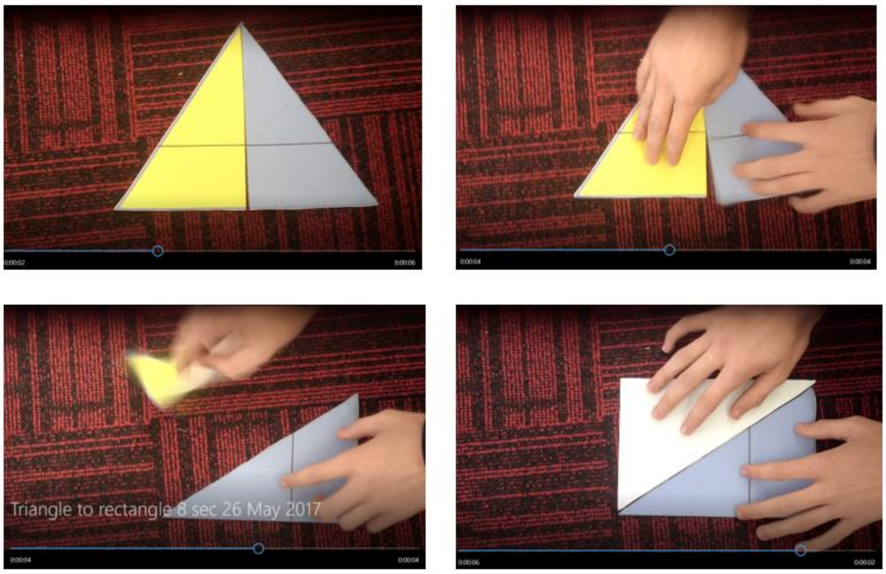



*Figure F.4.* Four stills from Toby and Sally's 8-second video on transforming a triangle into a rectangular area for easier area computation.

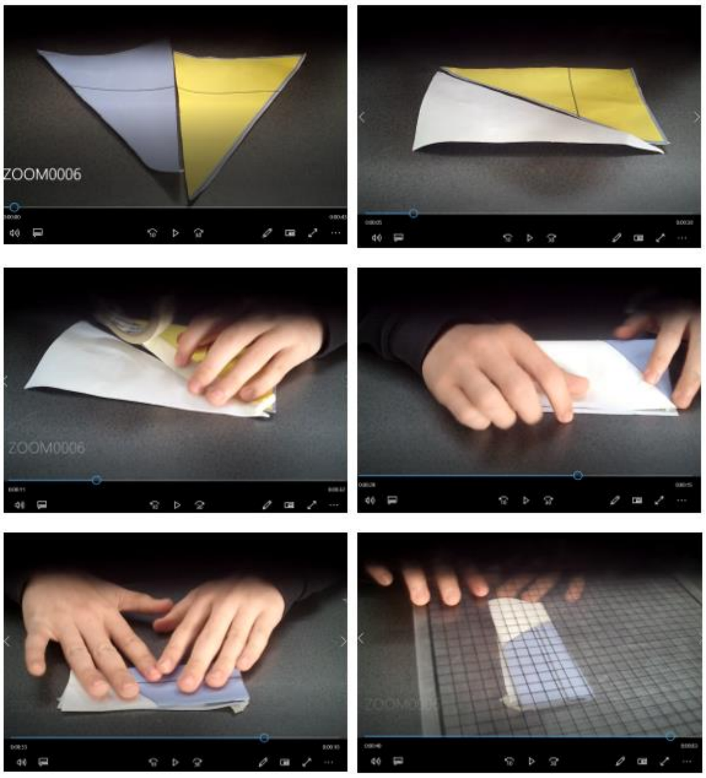



*Figure F.5.* Six stills from Toby and Ethan's 43-second video on finding a quarter of an equilateral triangle.

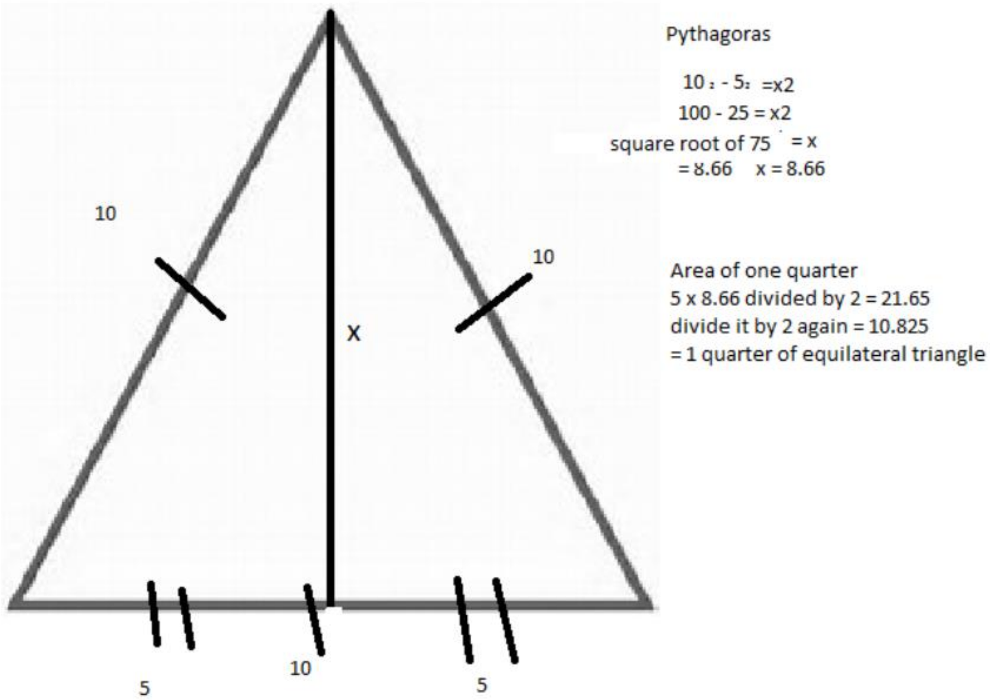



*Figure F.6.* Zach's workings to find a quarter of a triangle.

In Group 3, Hunter, Nathan, Maddison, Jacob, and Logan worked on creating fraction comparison pairs for a competition facility within the LMS hosting the e-learning module.

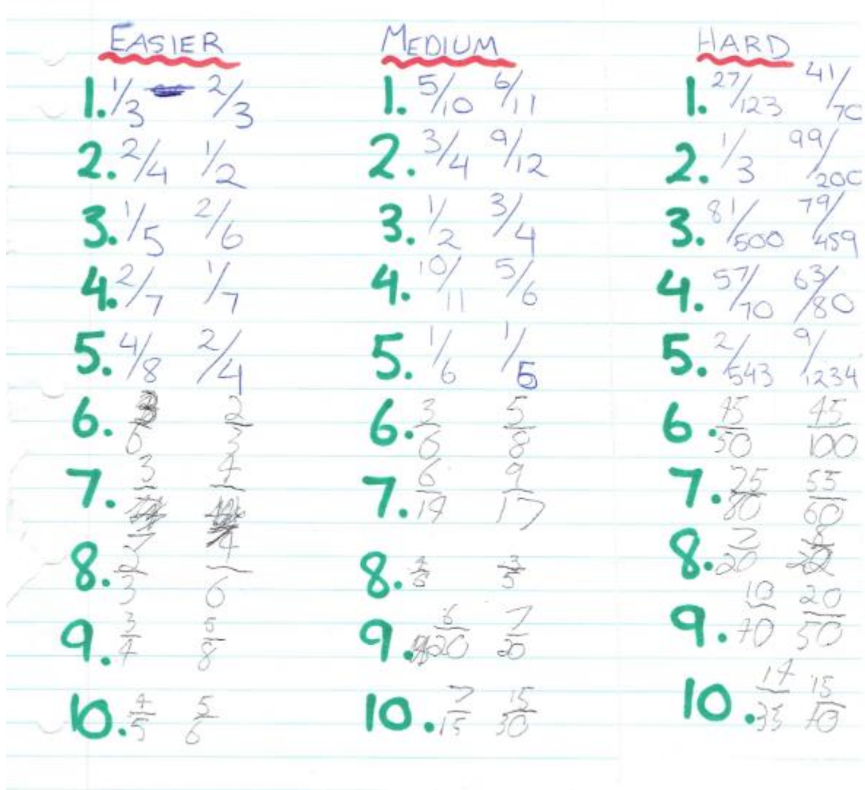



*Figure F.7.* Group 3's easier, medium and harder fractions comparison pairs

In Group 4, the fractions game, 'Knock off', was produced by Lissy and Siobhan. Samuel and Ryan were in this group too but did not appear to significantly contribute. Students were shown a similar game involving integers and subtraction and they needed to modify it for fractions and produce the instructions. This was a game for end users of the e-learning module to download and was played by students in Lesson 7 of this study.

Game-FRACTIONS KNOCK-OFF

Game aim: To have the most numbers covered with your tokens when the game ends

Players: 2 players only

Equipment:

- 2x 6-sided dice
- Fractions Strip (at bottom of page)
- Mini tokens

End of game: When every number is covered by a token

Play:

1. Player 1 rolls both dice and decides which number rolled will be the denominator and which would be the numerator. It can be put any way.
2. Player 1 then looks for their number on the Fractions Strip (bottom of page), whether it is that exact fraction or an equivalent fraction.
3. Player 1 places their token on the fraction that they rolled.
4. Player 2 then roles the dice and play continues. If a player roles a fraction/ number that is already taken by a token, play continues on to the next player.
5. When all fractions are cover, each player counts up his/her counters on the Fractions Strip. Player with the most counters wins the game.

Examples: Player 1 rolls a 4 and a 3. They can either place their token on ¾ or 4/3 (which simplifies to 1 1/3)

| | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $\frac{1}{6}$ | $\frac{1}{5}$ | $\frac{1}{4}$ | $\frac{2}{5}$ | $\frac{1}{3}$ | $\frac{1}{2}$ | $\frac{3}{5}$ | $\frac{2}{3}$ | $\frac{3}{4}$ | $\frac{4}{5}$ | $\frac{5}{6}$ | 1 | $1\frac{1}{5}$ | $1\frac{1}{4}$ | $1\frac{1}{3}$ | $1\frac{1}{2}$ | 2 | $2\frac{1}{2}$ | 3 | 4 | 5 | 6 |

*Figure F.8.* Lissy and Siobhan's downloadable fractions game, 'Knock off', including instructions

**Student generated animations**

All students contributed to animations but not all to each one. Below is a link to three brief student-generated animations in one video clip:

(i) stop-motion animation of fractions title (most students contributed);

(ii) digital animation of sequential unit fractions represented three ways — part-whole, measure (number line) and symbolically (numbers) (Isabella, Lissy, Toby, Zach, Logan and Jacob contributed); and

(iii) stop-motion animation of inverse proportions shown with the part-whole concept (the great the denominator, the smaller the fraction size) (created by Logan, Ethan and Samuel):

- https://youtu.be/ky6KB3WyjYA

## *Appendix G*

## Exit Slip Responses ($n$ = 69) Arranged by Lesson and Whole Cohort Ranking

*Note:* Available via this link too: https://1drv.ms/x/s!AquYueLhRTEHjjYkUyPkMkBAapn0?e=HIEoks

### (1) Ranked Order Within Lessons

Key

| | | | | | | |
|---|---|---|---|---|---|---|
| Engaged in learning | Enjoying | Creating | Others help learning | Compliant engagement | Distracted | Computers good |
| Disengagement | Disaffection - bored | Too much passivity | Already known | Too hard - confusing | Social - not learning | Computers bad |

| Lesson | Engaged SR | Designator | I was most engaged when I was... | because | I was least engaged when... | because | Learning SR | Today I learnt about | It helped me learn when... | It interferred with my learning today when... |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | Ex-L4-1/12-Anon | working in our books drawing a shape | | it was boring | | 1 | nothing, I already knew what to do | nothing | You kept on talking and it was boring |
| Other part-whole areas | 1 | Ex-L4-2/12-Anon | writing in books | | it was boring | | 3 | stuff about fractions | we did stuff in books | |
| | 1 | Ex-L4-3/12-Anon | not here | | here | | 5 | stuff | thing | not shore |
| | 1 | Ex-L4-4/12-Anon | messing around | | watching/listening | | 5 | I knew it all | I already knew all of it | I wasn't learning |
| | 1 | Ex-L4-5/12-**Sally** | wheeling around, talking to friends, messing around | | looking at | | | | | |
| | 2 | Ex-L4-6/12-Anon | I don't know | | most of the time | | 1 | not sure | not sure | not sure |
| | 2 | Ex-L4-7/12-Anon | we were trying out quizzes and working in groups | | most other things | | 3 | dividing shapes into other shapes | | |
| | 2 | Ex-L4-8/12-Anon | working with group | | Everything else | | 3 | The certain things we will do | Nothing helped | Everything |
| | 3 | Ex-L4-9/12-Anon | working in our books | | it was boring | | 1 | dividing fractions | I already knew it | I got distracted |
| | 3 | Ex-L4-10/12-**Zach** | doing the activities | | there was explaining | | 4 | what group I'm in | When it came on the board | People talked |
| | 3 | Ex-L4-11/12-Anon | in front of the class | | people were talking | | 4 | fractions | I was in front of the class | |
| | 3 | Ex-L4-12/12-Anon | Doing the work in the book | | The talking went on | | | | | |
| 5 | 1 | Ex-L5-1/17-Anon | I wasn't | | I had a headache | | 2 | nothing | I didn't | I had a migrane |
| Groupwork problem solving | 1 | Ex-L5-2/17-Anon | Working with my group | | you were talking | | 3 | ? | We were in groups | nothing |
| | 2 | Ex-L5-3/17-Anon | Talking | | You were talking | | 1 | Nothing | I now everything | It was boring and people talked. |
| | 2 | Ex-L5-4/17-Anon | talking | | You were talking | | 1 | | I concentrated | People talked |
| | 2 | Ex-L5-5/17-Anon | Working | | Not working | | 3 | What were meant to do | Nothing | Nothing |
| | 2 | Ex-L5-6/17-Anon | In a group | | we were watching the powerpoint | | 3 | ? | We were in groups | Nothing |
| | 2 | Ex-L5-7/17-**Zach** | working | | teacher talking | | 4 | Triangles are anoying | My Brain is stuffed | People talked |
| | 2 | Ex-L5-8/17-Anon | Playing with | | | | | | | |
| | 3 | Ex-L5-9/17-Anon | working with groups. Visual representations Taking photos and videographer | | | | 3 | | | |
| | 3 | Ex-L5-10/17-Anon | doing work | | IDK | | 3 | STUFF | Thing happened | headache |
| | 3 | Ex-L5-11/17-**Toby** | working | | listening to Mrs evans talk | | 3 | Stuff | Things happened | people talked |
| | 3 | Ex-L5-12/17-Anon | Working | | The talking went on | | 3 | compaing fractions | Mrs Evans was helping | people were talking |
| | 4 | Ex-L5-13/17-**Siobhan** | We could start working | | the powerpoint was on | | 3 | how to find an unlaybed trigangle sides length | _ | sitting for a while |
| | 4 | Ex-L5-14/17-Anon | having a conversation about dice | | the dice were handed to me | | 3 | | | |
| | 4 | Ex-L5-15/17-Anon | Listening and contributing | | ethan threw things | | 4 | pies* | hunter showed me things | nothing |
| | 4 | Ex-L5-16/17-Anon | doing the work | | the powerpoint | | 4 | IDK | I had the sheet | Nothing |
| | 5 | Ex-L5-17/17-Anon | I was working with fractions | | The dice came out | | 4 | Fractions | _ | _ |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 7 Finishing groupwork, watching how-to videos and making own videos | 1 | Ex-L7-1/14-Anon | Working outside | | We were watching the videos | | 1 | Fractions | ? | ? |
| | 1 | Ex-L7-2/14-Anon | Never | | all the time | | 1 | nothing | Never | Mr. Cork yelled at me |
| | 1 | Ex-L7-3/14-Anon | playing with figit spinner | | watching videos | | 2 | ? | ? | ? |
| | 1 | Ex-L7-4/14-Anon | doing nothing | | Speci | | 2 | ? | ? | ? |
| | 1 | Ex-L7-5/14-Anon | asleep | | awake | | 3 | STUFF | thing | STuff. |
| | 2 | Ex-L7-6/14-Anon | making movies | | doing work | | 3 | Shapes | I did videos | I was bored |
| | 3 | Ex-L7-7/14-**Isabella** | On the computer doing the overview | | we just started the lesson | | 3 | How to use paint* | I was on the computer. Miss evans helped | when it was loud at people talking |
| | 3 | Ex-L7-8/14-Anon | filming and mucking around | | Most work except the computer | | 3 | shapes | I did it myself and with friends | Mr Cork took the dice off me |
| | 3 | Ex-L7-9/14-**Zach** | I did my work | | not doing my work | | 4 | the work ive done was slightly pointless | miss evans told me | People talked |
| | 4 | Ex-L7-10/14-**Jenna** | working | | couldn't understand | | 4 | Fractions | Ms.Evans explained | It was loud |
| | 4 | Ex-L7-11/14-**Toby** | making a video | | never | | 4 | fractions | it was quiet | people made noise while making the video |
| | 4 | Ex-L7-12/14-Anon | working | | nothing happened | | 4 | fractions | you talked to me | nothing |
| | 5 | Ex-L7-13/14-Anon | Writing the game instructions | | We were watching the videos | | 4 | Fractions | I watched the videos | Nothing today |
| | 5 | Ex-L7-14/14-**Siobhan** | working | | listening to videos | | 4 | using paint | _ | _ |
| 9 Rotation of four activities | 1 | Ex-L9-1/17-Anon | talking | it was boring | working | it was boring | 1 | fractions | | |
| | 1 | Ex-L9-2/17-Anon | Never | this is boring | Every part | This is boring | 1 | Nothing | Nope | Yes |
| | 1 | Ex-L9-3/17-Anon | stuff | things | I was | stuff | 2 | FRACTIONS | JOE | STEEEEE |
| | 2 | Ex-L9-4/17-Anon | making stop motion | it was somewhat fun | most of it | it was boring | 2 | nothing | ? | ? |
| | 2 | Ex-L9-5/17-Anon | Making fraction word | It wasn't difficult | Computer stuff | It was boring | 2 | ? | ? | ? |
| | 2 | Ex-L9-6/17-Anon | operating camera | ? | 20 question sheet | ? | 2 | fractions | ? | ? |
| | 2 | Ex-L9-7/17-Anon | working | | I wasn't | | 3 | CAMERAS | TEACHERS | NOTHING |
| | 2 | Ex-L9-8/17-**Jenna** | making stop motion @ fractions | it was fun | on computer | BC confusing | 3 | Fractions | I Got help | I got distracted |
| | 3 | Ex-L9-9/17-**Isabella** | on computer | I was concentrating | when I was bored | cause it was boring and not difficult | 2 | Not really anything | ? | People talked |
| | 3 | Ex-L9-10/17-Anon | Doing stuff | it was fun | Doing stuff on computers | i don't like it | 3 | ? | ? | ? |
| | 3 | Ex-L9-11/17-**Zach** | doing work | it was good | not doing work | it is friday | 3 | Stuff that I know | never | nothing |
| | 3 | Ex-L9-12/17-Anon | whole time | it was boring | whole time | it was boring | 3 | not much | not at all | never |
| | 4 | Ex-L9-13/17-**Siobhan** | building the word fractions (s) | it was easy | doing the powerpoint | I didn't get it | 3 | Fractions | using fractions | nothing |
| | 4 | Ex-L9-14/17-Anon | doig stuff | I was doing stuff | I wasn't doing stuff | I wasn't doing stuff | 3 | fractions | I was engaged | I didn't doing stuff |
| | 4 | Ex-L9-15/17-Anon | working | I was Doing something | Someone stole something | it was mean | 4 | fractions | | |
| | 5 | Ex-L9-16/17-Anon | Living | I could take place in the activity | dead | I couldn't do stuff | 3 | | indecipherable scribble' | |
| | 5 | Ex-L9-17/17-Anon | Showing equivalent fractions | Because it was easy | I was doing the powerpoint | I didn't/couldn't do it | 5 | Fraction | | |
| 11 Linking three fractions concepts | 1 | Ex-L11-1/9-Anon | Never | | Yeah | | 1 | things | No | Yeah |
| | 1 | Ex-L11-2/9-Anon | ? | | ? | | 3 | ? | ? | ? |
| | 3 | Ex-L11-3/9-Anon | outside | | listen | | 2 | Nothing | | |
| | 3 | Ex-L11-4/9-Anon | working | | | | 3 | | | |
| | 3 | Ex-L11-5/9-Anon | working | | | | 3 | measuring | | |
| | 3 | Ex-L11-6/9-Anon | doing work | | not doing work | | 3 | Stuff | We did stuff | People did stuff |
| | 4 | Ex-L11-7/9-Anon | Doing the powerpoint | | | | 4 | Fractions | Kate was helping me | |
| | 4 | Ex-L11-8/9-Anon | I did stuff | | idk | | 4 | Fractions | quiet | here |
| | 5 | Ex-L11-9/9-**Logan** | taking photos | | | | 4 | denominators in fractions | | |

*Figure G.1.* Exit slip responses of five lessons colour-coded by theme and sorted by self-rated (SR) engagement and learning level

## (2) Total Ranked Order

**Appendix G cont.**

Key

| | | | | | | |
|---|---|---|---|---|---|---|
| Engaged in learning | Enjoying | Creating | Others help learning | Compliant engagement | Distracted | Computers good |
| Disengagement | Disaffection - bored | Too much passivity | Already known | Too hard - confusing | Social - not learning | Computers bad |

| Rank order | Engaged SR | Designator | I was most engaged when I was... | because | I was least engaged when... | because | Learning SR | Today I learnt about | It helped me learn when... | It interferred with my learning today when... |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | Ex-L4-1/12-Anon | working in our books drawing a shape | | it was boring | | 1 | nothing, I already knew what to do | nothing | You kept on talking and it was boring |
| 2 | 1 | Ex-L7-1/14-Anon | Working outside | | We were watching the videos | | 1 | Fractions | ? | ? |
| 3 | 1 | Ex-L7-2/14-Anon | Never | | all the time | | 1 | nothing | Never | Mr. Cork yelled at me |
| 4 | 1 | Ex-L9-1/17-Anon | talking | it was boring | working | it was boring | 1 | fractions | | |
| 5 | 1 | Ex-L9-2/17-Anon | Never | this is boring | Every part | This is boring | 1 | Nothing | Nope | Yes |
| 6 | 1 | Ex-L11-1/9-Anon | Never | | Yeah | | 1 | things | No | Yeah |
| 7 | 1 | Ex-L5-1/17-Anon | I wasn't | | I had a headache | | 2 | nothing | I didn't | I had a migrane |
| 8 | 1 | Ex-L7-3/14-Anon | playing with figit spinner | | watching videos | | 2 | ? | ? | ? |
| 9 | 1 | Ex-L7-4/14-Anon | doing nothing | | watching videos and working | | 2 | ? | ? | ? |
| 10 | 1 | Ex-L9-3/17-Anon | stuff | things | I was | stuff | 2 | FRACTIONS | JOE | STEEEEE |
| 11 | 1 | Ex-L4-2/12-Anon | writing in books | | it was boring | | 3 | stuff about fractions | we did stuff in books | |
| 12 | 1 | Ex-L5-2/17-Anon | Working with my group | | you were talking | | 3 | ? | We were in groups | nothing |
| 13 | 1 | Ex-L7-5/14-Anon | asleep | | awake | | 3 | STUFF | thing | STuff. |
| 14 | 1 | Ex-L11-2/9-Anon | ? | | ? | | 3 | ? | ? | ? |
| 15 | 1 | Ex-L4-3/12-Anon | not here | | here | | 5 | stuff | thing | not shore |
| 16 | 1 | Ex-L4-4/12-Anon | messing around | | watching/listening | | 5 | I knew it all | I already knew all of it | I wasn't learning |
| 17 | 1 | Ex-L4-5/12-**Sally** | wheeling around, talking to friends, messing around | | looking at | | | | | |
| 18 | 2 | Ex-L4-6/12-Anon | I don't know | | most of the time | | 1 | not sure | not sure | not sure |
| 19 | 2 | Ex-L5-3/17-Anon | Talking | | You were talking | | 1 | Nothing | I now everything | It was boring and people talked. |
| 20 | 2 | Ex-L5-4/17-Anon | talking | | You were talking | | 1 | | I concentrated | People talked |
| 21 | 2 | Ex-L9-4/17-Anon | making stop motion | it was somewhat fun | most of it | it was boring | 2 | nothing | ? | ? |
| 22 | 2 | Ex-L9-5/17-Anon | Making fraction word | It wasn't difficult | Computer stuff | It was boring | 2 | ? | ? | ? |
| 23 | 2 | Ex-L9-6/17-Anon | operating camera | ? | 20 question sheet | ? | 2 | fractions | ? | ? |
| 24 | 2 | Ex-L4-7/12-Anon | we were trying out quizzes and working in groups | | most other things | | 3 | dividing shapes into other shapes | | |
| 25 | 2 | Ex-L4-8/12-Anon | working with group | | Everything else | | 3 | The certain things we will do | Nothing helped | Everything |
| 26 | 2 | Ex-L5-5/17-Anon | Working | | Not working | | 3 | What were meant to do | Nothing | Nothing |
| 27 | 2 | Ex-L5-6/17-Anon | In a group | | we were watching the powerpoint | | 3 | ? | We were in groups | Nothing |
| 28 | 2 | Ex-L7-6/14-Anon | making movies | | doing work | | 3 | Shapes | I did videos | I was bored |
| 29 | 2 | Ex-L9-7/17-Anon | working | | I wasn't | | 3 | CAMERAS | TEACHERS | NOTHING |
| 30 | 2 | Ex-L9-8/17-**Jenna** | making stop motion @ fractions | it was fun | on computer | BC confusing | 3 | Fractions | I Got help | I got distracted |
| 31 | 2 | Ex-L5-7/17-**Zach** | working | | teacher talking | | 4 | Triangles are anoying | My Brain is stuffed | People talked |
| 32 | 2 | Ex-L5-8/17-Anon | Playing with | | | | | | | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 33 | 3 | Ex-L4-9/12-Anon | working in our books | | it was boring | | 1 | dividing fractions | I already knew it | I got distracted |
| 34 | 3 | Ex-L9-9/17-**Isabella** | on computer | I was concentrating | when I was bored | cause it was boring and not difficult | 2 | Not really anything | ? | People talked |
| 35 | 3 | Ex-L11-3/9-Anon | outside | | listen | | 2 | Nothing | | |
| 36 | 3 | Ex-L5-9/17-Anon | working with groups. Visual representations Taking photos and videographer | | | | 3 | | | |
| 37 | 3 | Ex-L5-10/17-Anon | doing work | | IDK | | 3 | STUFF | Thing happened | headache |
| 38 | 3 | Ex-L5-11/17-**Toby** | working | | listening to Mrs evans talk | | 3 | Stuff | Things happened | people talked |
| 39 | 3 | Ex-L5-12/17-Anon | Working | | The talking went on | | 3 | compaing fractions | Mrs Evans was helping | people were talking |
| 40 | 3 | Ex-L7-7/14-**Isabella** | On the computer doing the overview | | we just started the lesson | | 3 | How to use paint* | I was on the computer. Miss evans helped | when it was loud at people talking |
| 41 | 3 | Ex-L7-8/14-Anon | filming and mucking around | | Most work except the computer | | 3 | shapes | I did it myself and with friends | Mr Cork took the dice off me |
| 42 | 3 | Ex-L9-10/17-Anon | Doing stuff | it was fun | Doing stuff on computers | i don't like it | 3 | ? | ? | ? |
| 43 | 3 | Ex-L9-11/17-**Zach** | doing work | it was good | not doing work | it is friday | 3 | Stuff that I know | never | nothing |
| 44 | 3 | Ex-L9-12/17-Anon | whole time | it was boring | whole time | it was boring | 3 | not much | not at all | never |
| 45 | 3 | Ex-L11-4/9-Anon | working | | | | 3 | | | |
| 46 | 3 | Ex-L11-5/9-Anon | working | | | | 3 | measuring | | |
| 47 | 3 | Ex-L11-6/9-Anon | doing work | | not doing work | | 3 | Stuff | We did stuff | People did stuff |
| 48 | 3 | Ex-L4-10/12-**Zach** | doing the activities | | there was explaining | | 4 | what group I'm in | When it came on the board | People talked |
| 49 | 3 | Ex-L4-11/12-Anon | in front of the class | | people were talking | | 4 | fractions | I was in front of the class | |
| 50 | 3 | Ex-L7-9/14-**Zach** | I did my work | | not doing my work | | 4 | the work ive done was slightly pointless | miss evans told me | People talked |
| 51 | 3 | Ex-L4-12/12-Anon | Doing the work in the book | | The talking went on | | | | | |
| 52 | 4 | Ex-L5-13/17-**Siobhan** | We could start working | | the powerpoint was on | | 3 | how to find an unlaybed trigangle | – | sitting for a while |
| 53 | 4 | Ex-L5-14/17-Anon | having a conversation about | | the dice were handed to me | | 3 | | | |
| 54 | 4 | Ex-L9-13/17-**Siobhan** | building the word fractions (s) | it was easy | doing the powerpoint | I didn't get it | 3 | Fractions | using fractions | nothing |
| 55 | 4 | Ex-L9-14/17-Anon | doig stuff | I was doing stuff | I wasn't doing stuff | I wasn't doing stuff | 3 | fractions | I was engaged | I didn't doing stuff |
| 56 | 4 | Ex-L5-15/17-Anon | Listening and contributing | | ethan threw things | | 4 | pies* | hunter showed me things | nothing |
| 57 | 4 | Ex-L5-16/17-Anon | doing the work | | the powerpoint | | 4 | IDK | I had the sheet | Nothing |
| 58 | 4 | Ex-L7-10/14-**Jenna** | working | | couldn't understand | | 4 | Fractions | Ms.Evans explained | It was loud |
| 59 | 4 | Ex-L7-11/14-**Toby** | making a video | | never | | 4 | fractions | it was quiet | people made noise while making the |
| 60 | 4 | Ex-L7-12/14-Anon | working | | nothing happened | | 4 | fractions | you talked to me | nothing |
| 61 | 4 | Ex-L9-15/17-Anon | working | I was Doing something | Someone stole something | it was mean | 4 | fractions | | |
| 62 | 4 | Ex-L11-7/9-Anon | Doing the powerpoint | | | | 4 | Fractions | Kate was helping me | |
| 63 | 4 | Ex-L11-8/9-Anon | I did stuff | | idk | | 4 | Fractions | quiet | here |
| 64 | 5 | Ex-L9-16/17-Anon | Living | I could take place in the activity | dead | I couldn't do stuff | 3 | | indecipherable scribble' | |
| 65 | 5 | Ex-L5-17/17-Anon | I was working with fractions | | The dice came out | | 4 | Fractions | – | – |
| 66 | 5 | Ex-L7-13/14-Anon | Writing the game instructions | | We were watching the videos | | 4 | Fractions | I watched the videos | Nothing today |
| 67 | 5 | Ex-L7-14/14-**Siobhan** | working | | listening to videos | | 4 | using paint | – | – |
| 68 | 5 | Ex-L11-9/9-**Logan** | taking photos | | | | 4 | denominators in fractions | | |
| 69 | 5 | Ex-L9-17/17-Anon | Showing equivalent fractions | Because it was easy | I was doing the powerpoint | I didn't/couldn't do it | 5 | Fraction | | |

*Figure G.2.* Exit slip responses (*n* = 69) across five lessons, colour-coded by theme and sorted by self-rated (SR) engagement and learning level

# *Appendix H*

## Questionnaire Responses ($n$ = 15) Colour-Coded by Theme

*Please note.* The questionnaire and exit slip data are available online via this link:

https://1drv.ms/x/s!AquYueLhRTEHjjYkUyPkMkBAapn0?e=HIEoks

For an overview of colour-coded themes, please see Figures H.1 and H.2 below.

Key

| | | | | | | |
|---|---|---|---|---|---|---|
| Engaged in learning | Enjoying | Creating | Others help learning | Compliant engagement | Distracted | Computers good |
| Disengagement | Disaffection - bored | Too much passivity | Already known | Too hard - confusing | Others hinder learning | Computers bad |
| Pointlessness | Frustrating | Not fun | Childish | Suggestion | | |

Figure H.1. Student questionnaire responses colour-coded by first theme.

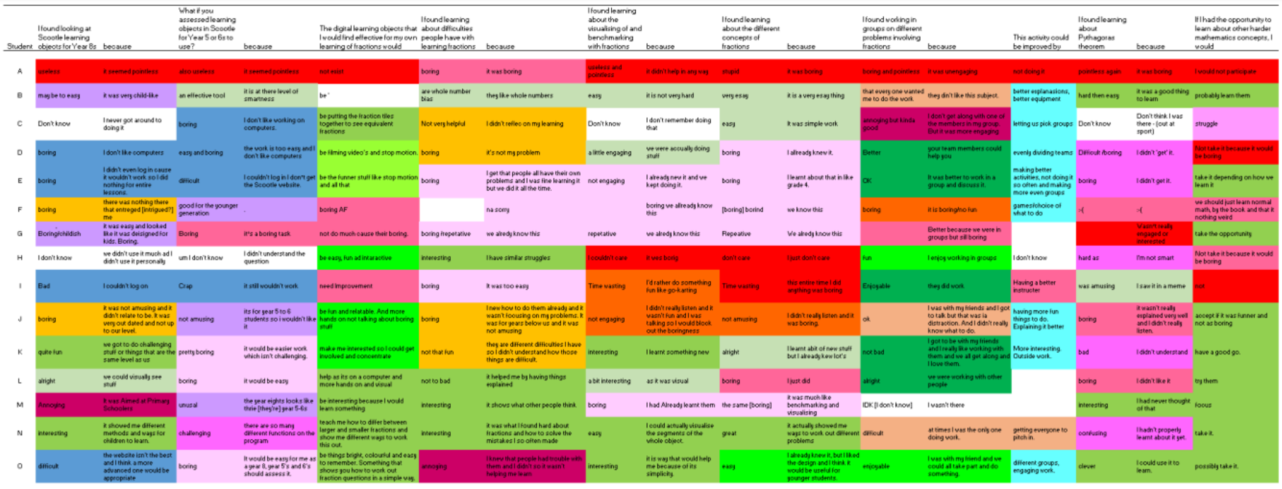


Figure H.2. Student questionnaire responses colour-coded by second theme.

*Appendix I*

Digital Learning Object (DLO) Appraisal Sheet

## Scootle or other Learning Object (LO) Appraisal

| Name of Learning Object | URL | Number | Opens? (Yes/No) | Easy to use (*****) | Age appropriate Yes/No | Notes |
|---|---|---|---|---|---|---|
| Shape fractions | http://www.scootle.edu.au/ec/viewing/L135/index.html | TLF-IDL135 | | | | |
| Fraction fiddle | http://www.scootle.edu.au/ec/viewing/L2800/index.html | TLF-IDL2800 | | | | |
| Wrong number explanation | http://topdrawer.aamt.edu.au/Fractions/Misunderstandings/Fractions-as-a-double-count/Wrong-number | NA | | | | |
| Equivalent fractions & numberline | http://www.amsi.org.au/ESA_middle_years/Year7/Year7_md/Year7_1d.html | TLF-IDM014343 | | | | |
| Equivalent Fractions Pointer | http://www.shodor.org/interactivate/activities/EquivFractionPointer/ | TLF-IDM012000 | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

Figure I. Digital Learning Object (DLO) Appraisal Sheet for Students

*Appendix J*

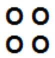
Pre-Test Questions on Fractions Concepts

FRACTIONS TEST

*Compiled questions main source: Charalambous and Pitta-Pantazi (2007)*

**Name:**________________________________ **Date:**__________

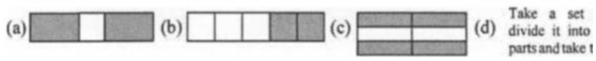
*A. Part of the whole*

1. If  represents 2/5 of a set of marbles, draw the whole set of marbles

(Baturo, 2004, July)

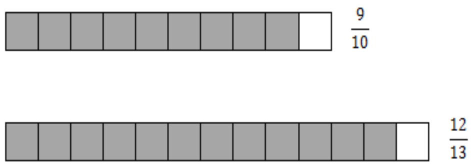
2. Which of the following correspond to 2/3?

   *Please circle correct response/s*.




(Boulet, 1998)

3. The following correctly shows why $\frac{12}{13}$ is bigger than $\frac{9}{10}$:




Answer *(please circle correct response):* *True* *False*

*Briefly explain your answer*:..........................................................................................

..........................................................................................................................

..........................................................................................................................

(adapted from Wright, Ellemor-Collins & Tabor, 2012)

*B. Ratio*

1. John and Mary are preparing orange juice for their party. Presented below are the recipes they used.

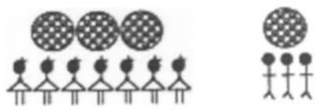
What recipe will make the juice the most 'orangey'?

| |
|---|
| John's recipe: Three cups of concentrate juice – five cups of water |
| Mary's recipe: Four cups of concentrate juice – eight cups of water |

Answer:_...............................

(adapted from Noelting, 1980)

2. Who gets more pizza, the boys or the girls?



Answer:_.................................

(Lamon, 1993; Marshall, 1993)

*C. Operator*

1. Without carrying out any operation, decide whether the following statement is correct:

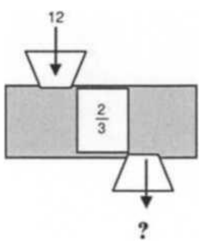
'If we divide a number by four and then multiply the result by 3 we are going to get the same result we would get if we multiplied this number by $\frac{3}{4}$'

Answer *(please circle correct response)*: True False

(Marshall, 1993)

2. The following diagram represents a machine that outputs 2/3 of the input quantity.

Which is the output quantity if the input quantity is equal to 12?




Answer:_.................................

(Davis, Hunting, & Peam, 1993; Lamon, 2012)

*D. Quotient*

1. Decide whether the following statement is correct or not:

   '2/5 is equal to the quotient of the division 2 divided by 5'

   Answer *(please circle correct response)*: True False

(Kieren, 1993)

(a) Three pizzas are evenly divided among five youths. How much pizza will each youth get?

Answer:______________

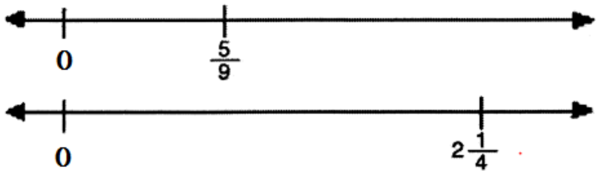
(b) Four pizzas were evenly shared among some friends. If each of them gets 4/7 of the pizza, how many friends are there altogether?

Answer:______________

(Behr, Hard, Post, & Lesh, 1993)

*E. Measure*

1. Locate number one on each of the following number lines




(adapted from Lamon, 2012)

2. Name one fraction that appears between $\frac{1}{10}$ and $\frac{1}{11}$

   Answer:______________

(adapted from Lamon, 2012)

3. Which of the following are numbers? (please circle)

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 4 | A | $ | 1.7 | 16 | ½ | $1\frac{4}{5}$ | 0.006 | | 47.5 | % |

(Charalambous & Pitta-Pantazi, 2007)

*F. Operations*

1. Select (tick) the answer that represents the best estimation of the operation $6\frac{3}{4} \times 4\frac{3}{7}$ =

The product is between

(a) 18 and 24 ☐
(b) 24 and 26 ☐
(c) 27 and 32 ☐
(d) 33 and 40 ☐

(adapted from Philippou & Christou, 1994)

2. Select (tick) the answer that represents the best estimation of the sum of

$\frac{3}{11} + \frac{7}{9}$ =

The sum is closest to

(a) 1 ☐
(b) 20 ☐
(c) ½ ☐
(d) 10 ☐

*Briefly explain your thinking:* ..........................................................................

..........................................................................................................................

..........................................................................................................................

Find the results of the following

*(Show working. Express in simplest form and as a mixed number where applicable.)*

(a) $\frac{5}{8} + \frac{4}{5}$ = ......................

(b) 2 ÷ ½ = ......................

(Charalambous & Pitta-Panazi, 2007)

(c) 3 ¼ - $1\frac{5}{12}$ = ......................

(d) $\frac{3}{5} \times \frac{10}{3}$ = ......................

*G. Equivalent fractions*

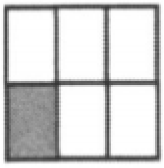
1. Fill in the missing number in each case:

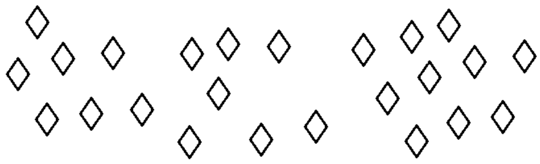
(a) $\frac{2}{3} = \frac{\square}{12}$

(b) $\frac{25}{40} = \frac{5}{\square}$

(Charalambous & Pitta-Pantazi, 2007)

2. Use the diagram on the right to represent an equivalent fraction to the one presented on the left





(Kyriakides & Charalambous, 2002; Ni, 2001)

*H. Rates*

1. If it takes me one hour to walk six kilometers, how fast am I walking? ..........................................

2. If it takes me four hours to walk two kilometers, how fast am I walking? ......................................

3. Which is going faster, Car A travelling 200 km in 2 ¼ hours or a Car B travelling 125 km in 1 ¼ hours?

   Answer: ....................

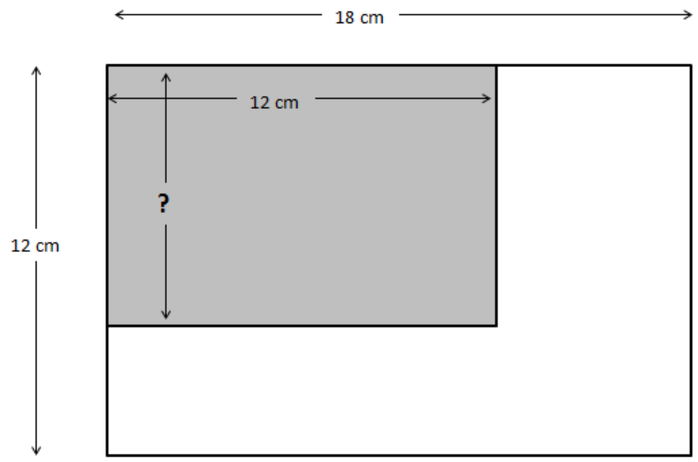
   *Explain your thinking*: ........................................................................................................................

   ........................................................................................................................................................

*H. Proportional thinking*

1. These two rectangles are in proportion.

What is the value of the missing measurement? .............................




2. It takes one person three days to paint two rooms.

*(Assume all people paint at the same rate)*

(a) How long would it take three people to paint to the two rooms?..................

(b) How long would it take two people to paint one room? .....................

THANK YOU FOR COMPLETING THE TEST

*Note.* Adapted from 'Drawing on a theoretical model to study students' understandings of fractions,' by C. Y. Charalambous and D. Pitta-Pantazi, 2007, *Educational Studies in Mathematics, 64*(3), Appendix. Copyright 2006 by Springer. Adapted with permission.

# *Appendix K*

## Pre and Post-Test of Fractions Concepts Results

| Student | Part-whole | | | | Ratio | | Operat'r | | Quotient | | | Measure | | | | Operations | | | | | | | | Equivalence | | | Rates | | | Proportional thinking | | | Pre-test tally | Post-test tally | Difference |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | Expl | 1 | 2 | 1 | 2 | 1 | 2a | 2b | 1a | 1b | 2 | 3 | 1 | 2 | Expl | Esti | 3a | 3b | 3c | 3d | 1a | 1b | 2 | 1 | 2 | 3 | 1 | 2a | 2b | | | |
| Tally | 10 | 6.5 | 2 | 1.5 | 7 | 8 | 3 | 6 | 6 | 5.5 | 7 | 7.5 | 5 | 0 | 5 | 2 | 4 | 3.5 | 3 | 5.5 | 4 | 3.5 | 3.5 | 10 | 8 | 7 | 8 | 3 | 2 | 1.5 | 7 | 0 | | | |
| Zach | 1 | 1 | 1 | 0.5 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0.5 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 25 | 23.5 | -1.5 |
| Siobhan | 1 | 0.5 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0.5 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 16 | 25 | 9 |
| Kate | 1 | 0.5 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0.5 | 1 | 0.5 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 14.5 | 13 | -1.5 |
| Lissy | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0.5 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 20.5 | 25.5 | 5 |
| Cynthia | 1 | 0.5 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.5 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 9 | 9 | 0 |
| Ethan | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 12 | 12.5 | 0.5 |
| Maddison | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0.5 | 1 | 0 | 0.5 | 0 | 0 | 0.5 | 1 | 1 | 0 | 0 | 0.5 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 16 | 14.5 | -1.5 |
| Hunter | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0.5 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 11.5 | 11 | -0.5 |
| Jenna | 1 | 0.5 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0.5 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 11 | 12 | 1 |
| Isabella | 1 | 0.5 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0.5 | 1 | 0 | 20 | 13 | -7 |

*Figure K.* Students' Pre-Test Scores on Fractions Concepts and the Pre-Test and Post-Test Tallies and the Difference

*Note.* Pre-test was administered on 21 April 2017 and post-test on 28 July 2017. Only students present at both tests are shown. Expl = explanation required; Esti = estimation required

*Appendix L*

Peer-reviewed conference paper on mathematics topics essential for success

# Essential Topics for Secondary Mathematics Success: What Mathematics Teachers Think[6]

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This preliminary study, to inform a larger study where Year 8 students create an online module for peers, surveyed mathematics teachers (n = 30) on essential mathematics topics: (a) Most critical for students' success; (b) most conceptually challenging for students; and (c) in which more fluency is needed; and also (d) their likelihood of considering an online course as an intervention. Fraction concepts, times tables and equation solving were found as most critical for success; students need more understanding of fractions concepts, and more fluency in both fraction concepts and times tables (up to 12 x 12). Online course use was supported to address teachers' concerns for students in essential mathematics topics.

This paper outlines a preliminary questionnaire-based study conducted on what topics mathematics teachers rate as most important and needed for students to succeed in their study of mathematics at secondary school. The results are needed to help inform the focus topic for a larger design-based intervention study in which Year 8 students create an online or e-learning module for peers. In this novel approach, Year 8 students change roles from content consumers to content creators. Learning outcomes and engagement levels will be tracked during the creation process. Also, if mathematics teachers are concerned about their students' understanding or fluency in essential mathematics topics, the questionnaire asked the likelihood of teachers considering an online course or module, as the major study aims to produce, to address those concerns.

## Background

Disengagement from mathematics by lower secondary students is widespread in Western nations (e.g., Middleton, 2013). In Australia, Martin et al. (2012) found that disengagement from mathematics in middle years students (Years 6 to 8; n = 1,601) was correlated with the following student and classroom factors: Low mathematics self-efficacy, low valuing of mathematics, reduced enjoyment and perceived classroom enjoyment, mathematics anxiety, and perceived classroom disengagement. Balfanz et al. (2007, p. 224) note that course failure in US lower secondary schools 'dramatically dampens a young adolescent's perceived control and engagement'. Furthermore, systemic secondary school practices in mathematics education may not be meeting the following young adolescents' needs that were mostly better met in primary school: a degree of autonomy; social interaction and relatedness; a close relationship with their teachers; small group work; challenging activities that require higher order thinking (Eccles et al., 1993); and the motivation of a hard, specific group goal (Locke & Latham, 2006). Giving students fresh opportunities to succeed while attention is drawn away from the individual performance and towards a challenging, relevant goal could assist students with concentrating on learning mathematics and not on any previous negative experiences with the subject. To this end, a novel approach has been devised such that a class of Year 8 students work together to produce an e-learning module for peers.

However, the topic on which the inaugural study is created needs to be selected carefully. Ideally,

[6] 2017. In A. Downton, S. Livy, & J. Hall (Eds.). 40 years on: We are still learning! *(Proceedings of the 40th annual conference of the Mathematics Education Research Group of Australasia)* pp. 237-244. Melbourne: MERGA.

to enhance the project's relevance, value and wider appeal, the topic needs to be one in which other more complex topics depend and is demonstrably essential and therefore valuable to school mathematics, further education, civic life, and the workplace. Enough students need to have some degree of difficulty with the topic such that the finished product, an e-learning module for local peer use, will be seen as a potentially worthwhile and challenging project to work on and a meaningful resource for end-users. In order to willingly commit to the research project, mathematics teachers also need to be able to appraise the topic as worthy of expending effort, time and resources.

Previous research supports that intervention on the topic of fractions is needed as it is often poorly understood across a broad spectrum of learners: primary school students (Daraganova & Ainley, 2012; Zhang et al., 2015); middle years (Years 5 to 8) students (Clarke & Roche, 2009; Stafylidou & Vosniadou, 2004); more senior high school students (Brown & Quinn, 2006; Kloosterman, 2010); and the general public (Basic Skills Agency, 1997; Reyna & Brainerd, 2008). The Longitudinal Study of Australian Children, Annual Statistical Report 2011(Daraganova & Ainley, 2012) included primary school teachers' ratings (n = 3,533) of children's numeracy skills (aged 8 to 9 years) and found that a quarter of children had either not yet (7%) or were just beginning (16%) to form an age-appropriate concept of fractions compared to, for example, half that amount either not yet (3%) or just beginning (9%) to form an age-appropriate concept of place value. In an open questionnaire asking Australian middle years students themselves (Years 5 to 8; n = 3562) about their single most important aspiration in mathematics, increased understanding of fractions, decimals and percentages was the highest response (Wilkie, 2016). However, missing from the literature and to better support the most needed topic in mathematics for middle years students is the standpoint of the mathematics teachers, which this preliminary study aims to help address.

There are other essential mathematics topics which are apposite contenders on which to base a novel intervention study in Year 8 mathematics. Referring to Martin et al. (2012), students need to see the value or relevance of mathematics in order to best engage in the subject. The following essential number and algebra topics are in the Australian Curriculum (AC) (Australia Curriculum, Assessment and Reporting Authority [ACARA], 2016), thereby are relevant to school-based education, and are mentioned in or inferred from the Programme for the International Assessment of Adult Competencies, Australia (Australian Bureau of Statistics, 2013), thereby are relevant to civic and workplace needs: Mental computation; multiplication facts (or times tables); estimating; negative numbers; place value of decimals; computing with decimals; percentage of a quantity; percentage change; converting between decimals, fractions and percentages; repeating patterns; growing patterns; order of operations; and solving equations. Also, the topic of fractions is quite broad and could be split into fractions concepts and computing with fractions.

While it is generally agreed that fluency in multiplication facts is an essential aim of primary education (e.g.,Wong & Evans, 2007), it is not clear what importance secondary mathematics teachers hold the automaticity and flexible use of multiplication or times tables facts, and which particular group of facts is important for students to learn or needs extra attention. A recent search in the US database, Educational Resources Information Center (ERIC), of peer-reviewed publications using the Boolean term 'and' with the ERIC subjects 'multiplication', 'computation' and 'mathematics instruction' revealed 77 articles, but none of these were research studies or discussion on which multiplication facts students need to be fluent in to recognize factors; support derived strategies; appreciate patterns (like the repeated digit pattern: 11, 22, 33…, of the eleven times table); or calculate commonly encountered multiple quantities quickly, like the number of months in multiple years. Researched support for the benefits of fluently learning multiplication facts only up to $10 \times 10$, as currently required in the AC, versus learning up to the twelve times tables of yesteryear was not found. An aim of this study is to survey what multiplication facts mathematics teachers deem as necessary for students to fluently learn.

A further aim of this preliminary study is to gauge the likelihood of mathematics teachers using an online or e-learning course — in the form of set of lessons/modules inclusive of competency-based assessment — to address students' deficits in understanding that prevent progress and success. In previous decades, this question would be invalid because the most consistent reason for mathematics teachers not using technology in their classrooms was lack of adequate access to computers (Forgasz, 2006b; Zammit, 1992). Now however, the computer to student ratio in Victorian government schools is nearly one-to-one (1:1.46) in primary schools and better than one-to-one (1:0.94) in secondary schools (Department of Education and Training [DET], 2016). It appears likely that students would engage with a digital resource. Young Australians are avid users of technology with 99% of 15 to 17 year olds in 2014-15 having access to the internet and an average of 18 hours per week use (Australian Bureau of Statistics, 2018). In Adelaide, Paris (2004) found that secondary students usually preferred online supplements to their classroom learning compared to pen and paper based tasks.

Online courses have multiple advantages for users. They allow for immediate feedback (Butler, Pyzdrowski, Goodykoontz, & Walker, 2008); and, easy, global and rapid connection to other resources (e.g., the digital learning objects repository, Scootle, by Education Services Australia [2017]). Online resources offer asynchronous (anytime) use; mobility; anonymity; and they can be text-based, use multimedia or be multimodal (Haythornthwaite & Andrews, 2011) and be potentially accessed by unlimited numbers of students. Pertinent to the main study here, digitally composed courses are highly editable and can be quickly and relatively cheaply published either locally or globally.

Use of online courses in US public high schools is widespread especially for the purposes of regaining credit for failed courses and completing core requirements in the main academic subjects (Clements, Stafford, Pazzaglia, & Jacobs, 2015). In Sydney region secondary schools, Neyland (2011) found a range of attitudes to online courses by computer coordinators, from aversion to sheer dedication. While there is some research on Australian mathematics teachers' beliefs affecting their choices to use technology in general (see Hennessy, Ruthven, & Brindley, 2005; Pierce & Ball, 2009), there is little on their willingness to use online or e-learning courses or modules as interventions where students need extra help in essential topics to progress and succeed in their studies.

There are five research questions for this study. Which topics do mathematics teachers rate as critical for success in secondary mathematics? In which topics do students need more conceptual understanding? In which topics do students need more fluency? What multiplication facts do students need to learn? Lastly, what is the likelihood of mathematics teachers offering an online course to their students to increase their understanding of mathematics topics required for success in secondary mathematics?

## Method and data analysis

A questionnaire survey was conducted at the 2015 annual Mathematics Association of Victoria (MAV) conference in Melbourne. Teachers of mathematics were approached and asked to complete a brief questionnaire about the most important topics required for secondary students' success in mathematics. The survey was anonymous, but respondents were asked to indicate the year levels in mathematics they had taught in the last five years. Space was provided for participants to record any further thoughts. Respondents were approached at morning tea break. Teachers were asked to tick the top three mathematics topics in three columns:

1. Topics critical for mathematics success in secondary mathematics
2. Topics in which students need more conceptual understanding
3. Topics in which students need more fluency

The following topics, each with sub-topics in italics, were included as choices: Mental computation (including *using known facts flexibly*; *time tables* - with a grid to select any or all from 2 to 12; and *estimating*); negative numbers (*computing with negative numbers*); fractions (including two subtopics of *understanding all fractions concepts*; and *computing with fractions*); decimals (including *place value of decimals*; and *computing with decimals*); percentage (including *percentage of a quantity*; *percentage change*; and *converting between decimals, fractions and percentages*); algebra (including *repeating patterns*; *growing patterns*; *BODMAS* [i.e., order of operations – brackets, orders, division, multiplication, addition and subtraction]; and *solving equations*); and other.

Despite asking participants to tick the top three topics in each column, some ticked more and some less. Three respondents selected more than three topics per column. In these cases, so that no one participant's scores dominated the results, the total score of three was divided evenly across each of that respondent's responses for that column. For example, one participant ticked six subtopics (only the top three were requested per column), and as such each selected subtopic was assigned 3/6 = 0.5 points. One respondent selected less than three subtopics for one column and his or her score was not altered.

A further section asked respondents the following question to rate with yes, no or maybe: 'If an online course or module was available to help address the above concerns you have for your students, would you be most likely to consider: Using it in your classroom; setting it as homework; or mention it as a resource that students can follow up in their own time?'

Indicating a concern with the questionnaire, the two subtopics, mental computation and times tables, were quite often ticked ambiguously for the first column which prompted for the topics critical for secondary mathematics success (6 out of 22 respondents who selected these two topics did not respond clearly, for example, ticking mental computation, but not times tables, then selecting 'all' for times tables) and in those cases, each of these two sub-topics was assigned a score of 0.5. This was not an issue for the conceptual understanding and fluency prompting columns that were marked unambiguously for both times tables and mental computation. Reported tallied scores which included averaged data were rounded to the nearest whole number to better reflect the precision of that data.

## Results

Thirty completed surveys were collected. All teachers surveyed had taught either upper primary mathematics (Years 5 and 6) or secondary mathematics (Years 7 to 12), with the greatest majority teaching from Year 9 through to senior secondary (Years 11 and 12) mathematics. One secondary teacher had retired more than five years prior to the survey whereas all others had been teaching in the last five years. No respondents had taught mathematics at preschool or at a technical and further education (TAFE) college. One respondent had written 'VCE equivalent' for year level of mathematics taught and his or her data was included under 'General mathematics'.

The mathematics levels taught by number of respondents in the last five years were as follows: Early years to Year 4 (2); Years 5 and 6 (3); Year 7 (9); Year 8 (11); Year 9 (15); Year 10 (18); Foundation or Essential mathematics (4); Further mathematics (16); General mathematics (16); Mathematics methods (17); Specialist mathematics (7); university level mathematics (7); Technical and Further Education (TAFE) mathematics (0); and Online (1).

In answer to the prompt, 'I think the following three maths topics… are critical for success in secondary maths: (Tick your top 3)', the highest scoring topics were the following: Understanding all fractions concepts (14/30); times tables (13/30); and solving equations (13/30). The clear choice in which the 30 surveyed teachers thought students need more conceptual understanding was fractions concepts. It was selected sixteen times as one of the top three. Other choices selected with about half the frequency of the top choice were computing with negative numbers, place value of decimals, growing patterns and solving equations. The mathematics topic choices for which the 29 surveyed teachers (one respondent did not complete this section) thought students need more fluency was in fractions concepts (chosen 13 times) and times tables (chosen 11 times). Computing with fractions and solving equations were the next most frequent choices. See Figure1.

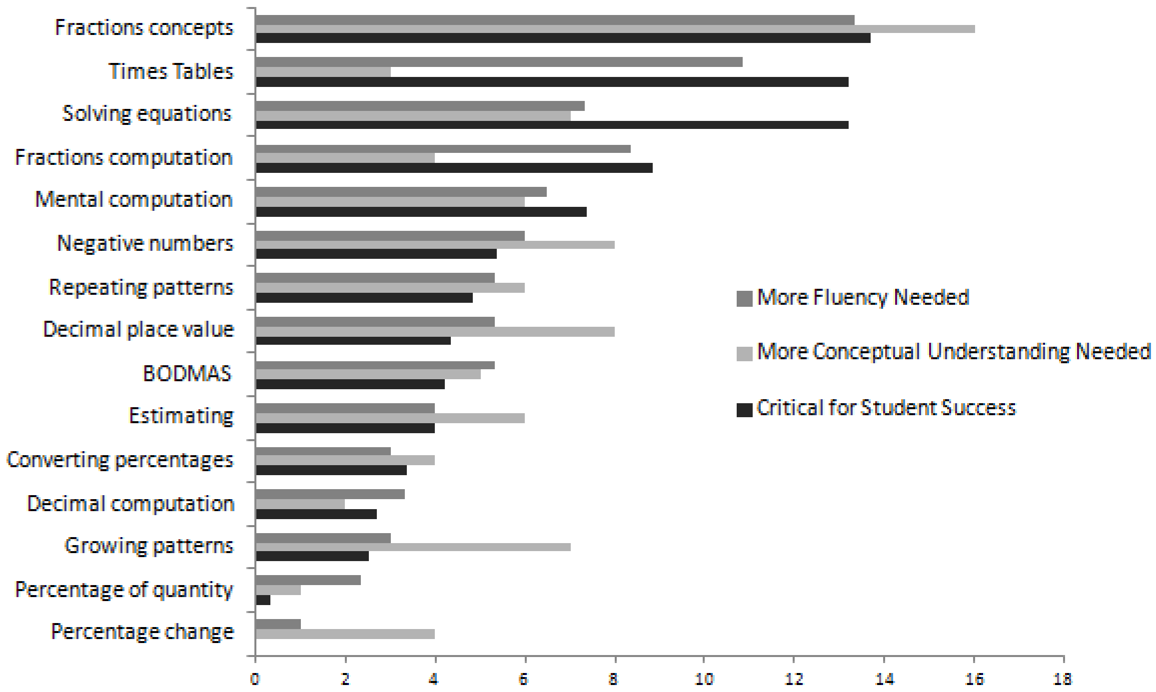


*Figure 1.* Mathematics teachers' appraisals (n = 30) of essential mathematics topics most critical for success, and in which there are student deficits in conceptual understanding or fluency.

Where times tables was selected across all three categories - more fluency needed; more conceptual understanding needed; or critical for student success; - the majority of selections for times tables was 'all' (24 out of 33 total selections), meaning here the multiplication factors from two to twelve. However, in about one fifth of instances, the selection of which particular times tables required was simply omitted, and one respondent selected factors from two to ten and another indicated that only the seven and eight times tables required further improvements in fluency for students.

Most respondents selected that they would consider using an online course in their classroom to support students with difficulties they had identified in essential mathematics (18 selected yes; 4 selected no; & 5 selected maybe). Most respondents would also consider setting an online course for homework (yes: 16; no: 4; & maybe: 4) and as a resource for students to pursue in their own time (yes: 16; no: 2; & maybe: 3).

## Discussion and conclusion

The questionnaire results successfully confirmed that fractions concepts is the best choice for the focus intervention topic for the larger study involving the co-creation of an online module by Year 8 students for peers. Fractions concepts was selected as the most frequent choice by secondary and middle years mathematics teachers across all three categories - critical for success in secondary mathematics, more conceptual understanding is required and more fluency is required. The findings support earlier research (Basic Skills Agency, 1997; Brown & Quinn, 2006; Clarke & Roche, 2009; Kloosterman, 2010; Reyna & Brainerd, 2008; Stafylidou & Vosniadou, 2004; Zhang et al., 2015) which showed that fractions concepts are poorly understood by many students and the general public. Furthermore, the middle years and secondary mathematics teachers' perspectives found here align with that of primary teachers' appraisals (Daraganova & Ainley, 2012) and that of middle years students themselves (Wilkie, 2016) that fractions concepts are often the most problematic for students.

Despite the small number of participants (n = 30), the non-random participant selection and the questionnaire layout initially prompting ambiguity in the responses between times tables and using known facts flexibly (mental computation), there is, albeit qualified, support for students increasing their fluency in times tables in general and learning multiplication facts with factors up to twelve. The majority (73%) of selections for times tables was ‘all’, meaning here the multiplication factors from two to twelve. However, the questionnaire did not include the multiplication facts for zero and one, and did not allow for easy, explicit choice between students knowing just up to the single digit factors (0 through to 9); from zero to ten; the products up to 100 (e.g., $0 \times 99 = 0$, $3 \times 3 = 9$, $5 \times 15 = 75$, $48 \times 2 = 96$); a concentration on prime number factors and deriving the rest; or any other possibility or combination. Nonetheless, especially in the dearth of information and research on this in the literature, it warrants further exploration as to what secondary mathematics teachers regard as the most important multiplication facts for students to be taught, learn, understand, practice, recall and be able to fluently use, and why.

There was strong support for considering the use of an online course to address concerns respondents had for their students in essential mathematics topics. This augurs well for finding support from mathematics teachers for the creation or use of an online course in their classrooms and ties in with Paris’(2004) finding that the students themselves prefer web-based rather than pen and paper based supplements. However, there is only scant research on the use of online or e-learning courses as interventions in Australian high schools. This raises the following questions: What online intervention courses are being used; what criteria do teachers use when selecting an online course for students; and for what topics do teachers seek online courses for their students?

If further research with a wider participant base replicates the findings here, that both fractions concepts and multiplication fact fluency are not only vital for secondary mathematics success but also merit remedial intervention, then perhaps a broader level intervention for improving fractions fluency and conceptual knowledge and multiplication fact fluency in lower secondary school, or earlier, is warranted. Online interventions have the advantage of cheaply and quickly being made available to unlimited numbers of recipients as long as a central repository or other means for dissemination for such resources is available. Alternatively, the students themselves could, with assistance, create local resources they need to succeed in their mathematics education to share with peers, and in the process improve in their engagement with the subject.

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