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Unveiling Knowledge Gaps:
An Investigation into the Design and Implementation of
Video Hooks in the Science Classroom

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Table of Contents

List of Figures	viii
List of Tables	x
List of Acronyms and Abbreviations	xi
Declaration	xii
Abstract	xiii
Acknowledgements	xv
Chapter One: Introduction to the Research	1
1.1 Chapter Introduction	1
1.2 The Importance of Science Education	1
1.2.1 Economy	2
1.2.2 The Irish context	3
1.3 Science and Physics Education: The Problem of Static Student Numbers.....	4
1.4 Physics Video Hooks: A novel approach to increasing Attention, Interest and Engagement.....	6
1.4.1 Hooks	6
1.4.2 Educational Technology	7
1.4.3 Digital Video.....	8
1.4.4 Science Education Resource (SER) design team – Hook development	9
1.5 Biographical Motivation	10
1.6 Research Questions	11
1.7 Outline of Chapters	11
1.7.1 Ethical Considerations	14
1.8 Chapter Summary	15
Chapter 2: Literature Review	16
2.1 Chapter Introduction	16
2.2 Science and Physics in Ireland.....	16
2.3 Interest and Engagement as Core Educational Constructs	18
2.4 Hooks – An Introduction	20
2.4.1 Historical Development	20
2.4.2 5E Model.....	21
2.4.3 ARCS Model.....	22
2.4.4 Hooks	23
2.5 Chapter Summary	29
Chapter 3: Physics Video Hook Design Framework	30

3.1 Chapter Introduction	30
3.2 Instructional Design Framework.....	31
3.2.1 Analysis.....	32
3.2.1.1 The Irish Education System	32
3.2.1.2 Classroom Stakeholders.....	33
3.2.1.3 Educational Technology	34
3.2.1.4 Digital Video.....	35
3.2.2 Design	37
3.2.2.1 Cognitive load theory.....	38
3.2.2.2 Multimedia design	39
3.2.3 Development	41
3.2.3.1 Relevance.....	44
3.2.3.2 Questioning.....	46
3.2.3.3 Discrepancy.....	48
3.2.3.4 Novelty.....	49
3.2.3.5 Development: Build Summary	50
3.2.4 Enhanced Evaluation	51
3.3 Technical Enumeration of a Physics Video Hook	52
3.4 Implementation	53
3.5 Chapter Summary	54
Chapter 4: Theoretical Framework	56
4.1 Introduction.....	56
4.2 The Pedagogical Foundation of Hooks.....	56
4.3 Student Impact: Interest, Attention and Engagement	58
4.3.1 Interest.....	59
4.3.1.1 Introduction.....	59
4.3.1.2 Situational Interest	59
4.3.1.3 Individual Interest	61
4.3.2 Interest and Curiosity.....	63
4.3.3 Attention	64
4.3.4 Engagement.....	65
4.3.4.1 Emotional Engagement.....	66
4.3.4.2 Cognitive Engagement.....	66
4.3.4.3 Behavioural Engagement	66
4.3.4.4 Defining Engagement	67

4.4 Interplay between Constructs.....	68
4.4.1 Attention and Interest.....	68
4.4.2 Attention and Engagement.....	68
4.4.3 Interest and Engagement.....	69
4.5 Defining Constructs for the Purposes of this Research	70
4.6 Chapter Summary	71
Chapter 5: Methodology	73
5.1 Chapter Introduction	73
5.1.1 Characterising the Problem.....	73
5.1.2 Philosophical Stance of the Researcher	74
5.2 Methodological Requirements	77
5.2.1 Methodological Approach	77
5.3 Qualitative Approach	79
5.3.1 Iterative Qualitative Design	79
5.3.2 Qualitative Interventions.....	80
5.3.3 Criticism of Qualitative Approaches	80
5.3.4 Establishing Rigour and Validity in Qualitative Research	81
5.2.4.1 Rigour	82
5.3.4.2 Validity	82
5.3.5 Qualitative Methodological Strategy	84
5.3.6 Qualitative Methodological Selection and Rationale	85
5.4 Design-Based Research	88
5.4.1 Origins of Design-Based Research	88
5.4.2 DBR: An Introduction.....	89
5.4.2.1 Simultaneous Advancement of Theory and Design.....	91
5.4.2.2 Theory that ‘Works’	91
5.4.2.3 Cyclical Interventions	92
5.4.2.4 Authentic Contexts.....	93
5.4.2.5 Data Collection Methods	94
5.4.2.6 Continual Refinement	94
5.4.3 Criticisms of Design-Based Research.....	97
5.4.4 Physics Video Hooks – Design Cycles	98
5.4 Research methods	104
5.5.1 Triangulation.....	104
5.5.2 Pilot.....	105

5.6 Interviews.....	106
5.6.1 Design	107
5.6.2 Semi-structured Approach	108
5.6.3 Conducting the Interview.....	108
5.7 Observation.....	109
5.7.1 Observing Affective States	110
5.7.2 Observation Schedule	111
5.7.3 Field Notes	112
5.7.4 Writing Up and Analysis of Field Notes.....	113
5.7.5 Validity	114
5.8 Survey Methodology.....	115
5.8.1 Exit Cards.....	115
5.9 Group Interviews	116
5.9.1 Procedure	117
5.9.2 Validity	118
5.10 Teacher Journal.....	119
5.11 Research Journal.....	119
5.11.1 Reflexivity.....	120
5.12 Sampling Method - Overview.....	121
5.12.1 Sampling	122
5.12.2 Saturation	123
5.12.3 Sampling in Design Cycles.....	124
5.12.3.1 Design Cycle 1 – Pilot	124
5.12.3.2 Design Cycle 2.....	124
5.11.3.3 Design Cycle 3.....	124
5.13 Ethical Considerations	125
5.13.1 Incentives	127
5.14 Analysis.....	128
5.14.1 Data Analysis	128
5.14.1.1 Thematic Analysis	128
5.14.1.2 Pre-coding.....	129
5.14.1.3 Familiarisation	130
5.14.1.4 Analytic Memos.....	131
5.14.1.5 Coding.....	133
5.14.1.6 First Cycle Coding	134

5.14.1.7 Codebook	137
5.14.1.8 Second Cycle Coding	139
5.14.1.9 Second Cycle Coding – Theme Development	143
5.14.1.10 Quantitative Analysis of Qualitative Data	147
Chapter 6: Design Cycle 1	148
6.1 Chapter Introduction	148
6.2 Design Cycle 1: Implementation Strategy	148
6.2.1 Overview	148
6.2.2 Pedagogical Design.....	149
6.2.3 Physics Video Hook Design	149
6.2.4 Intervention Design.....	149
6.2.5 Conjecture Map.....	150
6.2.6 Methodology	151
6.2.7 Data Analysis	153
6.3 Design Cycle 1: Findings.....	154
6.3.1 Off the Hook? Introducing Technology to Pedagogy.....	154
6.3.2 Sling Your Hook: Confusion among the Digital Residents.....	156
6.3.3 Hook Again: Uncertainty Pertaining to the Physics Video Hook Design	159
6.4 Changes and Modifications toward Design Cycle 2.....	161
6.4.1 Physics Video Hook Design Modifications.....	162
6.4.2 Pedagogical Design Modifications	163
6.4.3 Methodological Design Modifications	165
6.5 Findings Summary	168
6.6 Chapter Summary	169
Chapter 7: Design Cycle 2	171
7.1 Chapter Introduction	171
7.2 Design Cycle 2: Implementation Strategy	171
7.2.1 Overview.....	171
7.2.2 Pedagogical Design.....	172
7.2.3 Physics Video Hook Design	173
7.2.4 Intervention Design Modifications	173
7.2.5 Conjecture Map.....	174
7.2.6 Methodology	174
7.2.7 Data Analysis	175
7.3 Design Cycle Two: Findings	176

7.3.1 The Scientific Method: The Pragmatic Implementation of Physics Video Hooks by Science Teachers.....	176
7.3.2 Pedagogical Strategies	179
7.3.2.1 Pre/Post strategies	181
7.3.2.2 Inquiry Based Learning.....	182
7.3.2.3 Segmentation.....	184
7.3.2.4 Post Revision Strategy	186
7.3.2.5 The Scientific Method: Continued Pragmatism.....	187
7.3.3 Design enabling Pedagogy.....	189
7.3.4 Unveiling Knowledge Gaps: The Development of the Student Impact Model	192
7.3.4.1 Introduction.....	192
7.3.4.2 Revealing Knowledge Gaps.....	193
7.3.4.3 Phase 1: Triggered Situational Interest	197
7.3.4.4 Phase 2: Maintained Situational Interest.....	203
7.3.4.5 Theoretical Positions and the Student Impact Model	208
7.3.5 Design and Pedagogy enabling the Student Impact.....	209
7.3.5.1 Questioning Design Element	209
7.3.5.2 Discrepancy Design Element	210
7.3.6 Prior Knowledge as the Anchor throughout Interventions	212
7.3.6.1 Introduction.....	212
7.3.6.2 Development of Prior Knowledge	213
7.4 Changes and Modifications toward Design Cycle 3.....	217
7.4.1 Physics Video Hook Design Modifications	218
7.4.2 Pedagogical Design Modifications	221
7.4.3 Methodological Design Modifications	221
7.4.4 The Emergence of Para-Hooks	223
7.5 Findings Summary	224
7.6 Chapter Summary	225
Chapter 8: Design Cycle 3	226
8.1 Chapter Introduction	226
8.2 Design Cycle 3: Implementation Strategy	226
8.2.1 Overview.....	226
8.2.2 Pedagogical Design.....	226
8.2.3 Physics Video Hook Design	227
8.2.4 Intervention Design Modifications	227

8.2.5 Conjecture Map.....	228
8.2.6 Methodology	229
8.2.7 Data Analysis	231
8.3 Design Cycle Three: Findings	232
8.3.1 Evolving Pragmatism: Reaching Plateaus and Crossroads within Instruction	232
8.3.2 Reinforcing Knowledge Gaps within the Complexity of the Science Classroom	238
8.3.3 Fine Lines: Traversing the Blurred Boundary between Confusion and Interest	246
8.3.4 Persistence and Positivity: Maintaining Situational Interest	252
8.3.5 Pedagogy as the Hinge in Differentiating the Student Impact.....	255
8.4 Chapter Summary	257
Chapter 9: Findings and Conclusions	258
9.1 Chapter Introduction	258
9.2 Pedagogical Contribution.....	258
9.3 Theoretical Contribution.....	261
9.4 Design Contribution.....	264
9.5 Defining Hooks and Para-Hooks	266
9.6 Conclusion	268
9.6.1 Significance of Contribution.....	268
9.6.2 Recommendations for Future Research	272
References.....	274
Appendices.....	314
Appendix A: Links to the Physics Video Hooks	314
Appendix B: Participant Recruitment.....	315
Appendix C: Research Tools	334
Appendix D: Analysis.....	343

List of Figures

Figure 2.1: Total number of student studying physics and biology in Ireland.....	17
Figure 3.1: Signalling principle in video hook.....	39
Figure 3.2: Multimedia principle in video hook.....	41
Figure 3.3: Relevance design element in video hook.....	46
Figure 3.4: Discrepancy design element in video hook.....	49
Figure 4.1: Mitchell’s model of situational interest.....	60
Figure 4.2: Hidi and Renninger’s (2006) four-phase model of interest development.....	62
Figure 4.3: Proto-theoretical model of video hooks.....	71
Figure 5.1: Iterative process of DBR.....	90
Figure 5.2: Iterative cycles of DBR.....	100
Figure 5.3: Illustration of pre-codes developed.....	130
Figure 5.4: Screenshot of analytical memos.....	132
Figure 5.5: Screenshot of first cycle coding.....	136
Figure 5.6: Screenshot of codebook.....	138
Figure 5.7: Screenshot of NVivo 10 with node list.....	140
Figure 5.8: Screenshot of coding stripes.....	141
Figure 5.9: Screenshot of annotation feature in NVivo 10.....	142
Figure 5.10: Hand drawn thematic map for design cycle 2.....	144
Figure 5.11: Revised thematic map for design cycle 2.....	145
Figure 6.1: Proto-theory for design cycle 1.....	150
Figure 6.2: Conjecture map for design cycle 1.....	151
Figure 6.3: Thematic map for design cycle 1.....	153
Figure 6.4: Proto-theory for design cycle 2.....	169
Figure 7.1: Proto-theory for design cycle 2.....	173
Figure 7.2: Conjecture map for design cycle 2.....	174
Figure 7.3: Thematic map for design cycle 2.....	176
Figure 7.4: Triggered and maintained phases of situational interest.....	197
Figure 7.5: Model of situational interest with emotional engagement.....	200
Figure 7.6: Model of situational interest with attention.....	202
Figure 7.7: Model of situational interest with cognitive engagement.....	206

Figure 7.8: Student impact model for design cycle 2.....	207
Figure 7.9: U shaped model of prior knowledge and interest.....	216
Figure 7.10: Illustration of cross curricular links.....	220
Figure 7.11: Proto-theory for design cycle 3.....	225
Figure 8.1: Proto-theory for design cycle 3.....	228
Figure 8.2: Conjecture map for design cycle 3.....	229
Figure 8.3: Thematic map for design cycle 3.....	232
Figure 8.4: Hook impact model for design cycle 2.....	238
Figure 8.5: Knowledge gap model with triggered situational interest.....	246
Figure 8.6: Hook impact model with confusion and cognitive engagement.....	252
Figure 8.7: Hook impact model for design cycle 3.....	254
Figure 9.1: Para-hook impact model for design cycle 2.....	262
Figure 9.2: Hook impact model for design cycle 3.....	263
Figure 9.3: Bespoke design model for thesis.....	271

List of Tables

Table 1.1: Overview of research gaps, methods and analysis.....	13
Table 2.1: List of all hook like phases in the literature.....	28
Table 3.1: List of all hook videos with description and duration.....	43
Table 3.2: Narration used throughout the CoG hook with specific time points.....	53
Table 3.3: Design phases followed in the creation of the physics video hooks.....	54
Table 5.1: Characteristics of DBR.....	96
Table 5.2: Table of teacher participants, school type, subjects taught and design cycles.....	101
Table 5.3: Breakdown of design cycles.....	104
Table 5.4: Analysis Framework.....	146
Table 6.1: Methodological changes between design cycle 1 and 2.....	167
Table 7.1: Methodological changes between design cycle 1 and 2.....	175
Table 7.2: Teacher participant's pedagogy in design cycle 2.....	179
Table 8.1: Intervention and associated pedagogy in design cycle 3.....	234
Table 8.2: Time hook was played in design cycle 2.....	238
Table 8.3: Response categories for exit cards (Question 1).....	239
Table 8.4: Response categories for exit cards (Question 2).....	243

List of Acronyms and Abbreviations

Design-Based Research.....	DBR
Science, Technology, Engineering and Mathematics.....	STEM
Science Education Resource.....	SER
World Health Organisation.....	WHO
National University of Ireland, Galway.....	NUI, Galway
British Educational Research Association.....	BERA
Professional Master of Education.....	PME
Biological Sciences Curriculum Study.....	BSCS
Teaching Enquiry with Mysteries Incorporated.....	TEMI
Practitioner Action Research.....	PAR
Attention, Relevance, Confidence and Satisfaction.....	ARCS
Virtual Reality.....	VR
Analysis, Design, Development, Implementation and Evaluation.....	ADDIE
Analysis, Design, Development, Enhanced Evaluation.....	ADDE*
Leaving Certificate Vocational Program.....	LCVP
Leaving Certificate Applied.....	LCA
Department of Education and Skills.....	DES
Cross Curricular Links.....	CCL

Declaration

I hereby certify that the work presented, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy, is original and entirely my own work, except as otherwise acknowledged in the text. The material has not been submitted, either in whole or part, for a degree at this or any other university.

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January 2017

Abstract

Both internationally and in Ireland, the role science plays in the advancement of economic and technological endeavours cannot be undervalued. Nevertheless, in developed countries, established trends of decreasing student numbers are a continual point of concern. In response, efforts to influence student subject choices, guided toward the sciences and in particular physics, are commonplace. Modern research positions, underscore the key capacity of interest and engagement as key affective and cognitive constructs that can mediate subject selection. Furthermore, the quality and content of instruction are denoted as the largest determinants of the former constructs. The given context affords the necessity and opportunity to examine pedagogical methodologies that augment interest and engagement situated in the science classroom.

This study examines hooks. Hooks represent an area of instruction that has been traditionally understudied in educational literature, yet, are central aspects of instructional frameworks and colloquially present in teachers' toolkits. Based on the limited literature, they can be defined as a short instructional method utilised at the beginning of instruction to augment interest, engagement and attention among the student body. Employing a Design-Based Research (DBR) methodology, in which both theory and design are advanced in light of practical findings resultant from authentic classroom contexts, this research sets out to explore nascent research areas, including the design, construction and implementation of hooks, a bespoke instructional method/tool grounded in the requirements of all stakeholders in the science classroom.

In line with the DBR process, a theoretically informed design; the physics video hook artefact was systematically placed in the naturalistic classroom context using three iterations of interventions, coupled with appropriate data collection tools over a period of four years. In sum, 43 interventions were enacted with 12 teachers and their respective students.

The results obtained indicate that the implementation of hooks resonated more so with teachers' pragmatic classroom requirements rather than the theoretical derivations of hook based pedagogies. Placing the video hook design artefact at the start of the lesson as an all-encompassing hook, proved ineffective in terms of the predicted hook impact of attention, interest and engagement. The hook required integration into the wider pedagogy as teacher participants employed a variety of teaching methods with the design artefact to promote inquiry, consolidation of learning and revision. With this, the study theoretically forwards the

previous definition of hooks to accommodate ‘para-hooks’, a hook that is not used as an introductory moment within instruction. Emergent with this finding was the key role of developing students’ prior knowledge as the ‘hinge’ around which the desired hook reaction of interest, engagement and attention could be created. The contribution aligns with modern theories pertaining to the formation of knowledge gaps through discrepancy, a fundamental design asset of the hooks. Legitimizing findings, students indicated that the phenomena displayed in the video hooks were the most interesting aspects of their respective lessons. The study ends with implications and recommendations derived from these conclusions.

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Chapter One: Introduction to the Research

1.1 Chapter Introduction

The opening chapter of this thesis demarcates the background to the research and the rationale for undertaking it. It firstly outlines the importance of science education from both international and Irish perspectives and how, presently, science education is central to economic and societal needs. With this background, the chapter subsequently explores the pertinent issues faced by developed countries in terms of declining student numbers in science and in particular physics. The discussion is situated within the general conversation of student interest and engagement in science as key drivers of current trends. This opens up the novel possibilities afforded by ‘hooks’, developed through a collaborative design project and based on video technology, which has the potential to positively impact pedagogical instruction and students’ interest and engagement within science and physics classrooms.

The chapter concludes with a summary of the thesis structure and how the research is designed to answer the thesis’ primary research question – How can physics video hooks be designed and implemented to generate student attention, interest and engagement in physics?

1.2 The Importance of Science Education

Scientific literacy represents an appreciation of socio-scientific domains (Sadler and Zeidler 2009). It is positioned by numerous authors that scientific literacy should be at the core of progressive and modern societies (Hampton and Licona 2001, Jidesjö *et al.* 2012, Osborne *et al.* 2003, Tytler 2007). In its broadest sense, scientific literacy has come to describe a desired familiarity between science and the general public. For this reason, it has become a goal of scientific educational reform (DeBoer 2000). The Organisation for Economic Co-operation and Development (OECD) has placed science alongside reading and mathematics as one of the three main literacy domains with the specific goal of ‘scientific literacy’ for all of science education (DES 2002). This is as a result of societal and environmental requirements over the past number of decades. Societies today, face scientific issues such as climate change, genetic modification and energy supply (Wieman and Perkins 2005). Moreover, Tytler (2007) draws attention to large scale moral and ethical issues such as stem cell research and inoculation. A population that is scientifically literate is needed to deal with science based social issues in an intelligent manner (Jidesjö *et al.* 2012). The ability to be able to make informed decisions in modern democracies and cultures with the capacity to critique scientific evidence and arguments is pivotal to a forward thinking social force (Osborne and Dillon 2008, Sjøberg 2002).

However, evidence suggests a widespread scientific ignorance among the general populous due to a diminishing interest in studying science (Osborne *et al.* 2003). This in turn is becoming a societal and educational concern. Hampton and Licona (2001) express such apprehensions and suggest that science instruction should not aim to produce scientists and doctors, but rather to help form students who are scientifically literate. Understanding science is not just about learning ‘concepts’ and ‘definitions’, rather, it is about achieving an insight into multidimensional frameworks that encompasses historical, philosophical and social aspects of the subject (Osborne 2002). Science and technical information is increasing at an exponential rate and information is consistently being redefined (Hampton and Licona 2001). Consequently, the promotion of science in school and in new curricula (NCCA 2011) in a favourable and interesting manner is becoming increasingly prominent (Osborne *et al.* 2003).

1.2.1 Economy

The previous section articulated the push to improve science education for the purposes of creating a scientifically literate populous, however, the impetus is also driven by competition between countries that believe economic growth is dependent on such literacy (DeBoer 2011).

Society is ever changing at an ever increasing rate (Elton-Chalcraft *et al.* 2008). Today, technology and science are core economic drivers (Ruiz *et al.* 2014, Sjøberg 2002). Technologists and scientists are fundamental to the development of research and innovation as a central foundation to economic prosperity (Ruiz *et al.* 2014). Economic concerns are connected to projected shortages in workforce requirements with an associated milieu of economic deficits (Jidesjö *et al.* 2012). It is positioned that increased participation and performance in Science, Technology, Engineering and Mathematics (STEM) fields is necessary to ensure that the flow of skilled workers into economies does not stagnate (Oon and Subramaniam 2011). The argument centres on the notion of the ‘STEM pipeline’ which, research evidence over the past ten years demonstrates, has not been flowing at a sufficient rate for future scientific and technological needs (Angell *et al.* 2004, Osborne and Dillon 2008, Tytler 2007). Compounding the issue, many developing economies are transitioning from being manufacture based to knowledge based (Blanton *et al.* 2006). Implications of such a transition, indicate increased competition across societies in which technology is the basis for economic growth and scientific innovation (Wieman and Perkins 2005). There is a growing demand internationally for science and in particular physics graduates (Angell *et al.* 2004) at a time when participation is low (Bybee and McCrae 2011).

The strategic global positioning of an economy is at stake if trends in the uptake of the physical sciences are not reversed (Hampden-Thompson and Bennett 2013). On a European level, there is a supply issue with regard to scientists in the labour force and an ever emerging trend of lowering student numbers in science (Osborne and Dillon 2008). Young people across Europe are moving away from science at all levels of education making it difficult for industry to hire engineers and scientists (Willingale-Theune *et al.* 2009). The Europe 2020 strategy aims to ameliorate such concerns by delivering high levels of employment, social cohesion and productivity so as to patch over the many weaknesses exposed in the EU economy by the recent economic downturn (ASTI 2013b). The European Commission has highlighted the need for more scientists to sustain desired levels of economic growth (Maltese and Tai 2011). It is postulated by Gago *et al.* (2004) that a shortage of scientists in research and development would restrict Europe's economic projections. In remedying such issues, the Europe 2020 strategy requires educational institutions to prepare knowledgeable and mobile individuals. Such educational reform accentuates the key role of science education in crafting new and emergent labour markets (ASTI 2013a).

Similar trends are replicated in the United States where the demand for STEM graduates has fostered a plethora of initiatives to encourage STEM-based economic activities (Franco *et al.* 2012). Throughout the economic crisis in the United States, calls for STEM graduates are abound as efforts to position the country as a world leader in research and development is a top concern (Harwell *et al.* 2015). Harwell *et al.* (2015) presents a twofold remediation strategy. Firstly, STEM education has to improve and secondly, the number of students choosing to study such fields throughout their education has to increase. In accordance, Osborne *et al.* (2008) states that declines in the number of students studying science is the justification behind a plethora of investigations into pupil's attitudes and views of science in educational research over the past 40 years. This is a prolonged trend as the vast population is dependent on high level expertise of a small cohort of individuals to drive innovation and raise the standards of living (Sjøberg 2002).

1.2.2 The Irish context

“Education is vital to Ireland's economic recovery” (Drudy, 2011, p. 174). Evidence suggests that due to a decline in the numbers employed in agriculture, a decrease in manufacturing and the collapse of the construction industry, as the previous economic drivers, Ireland has no choice but to invest in the development of a knowledge economy (Drudy 2011).

Walsh and Loxley (2014) refer to the shaping of higher education in Ireland as reacting to the dominant ‘knowledge based economy’ paradigm, one that rules Irish politics. This is obvious when examining a range of governmental strategy documents. The Irish government’s strategy for Science, Technology and Innovation (2006 – 2013) set out a vision for Ireland to become a knowledge economy by 2013, with one of its core ambitions to provide “solid sound foundations in education.” (DES, 2004, p. 2). The report focuses on science education with a number of recommendations, including increased participation in school science to achieve future economic goals (DES 2004). The problem of declining numbers of Irish science students was noted in 2002 by the Department of Education and Skills (DES 2002) and the issue still persists (ASTI 2013b, Bybee and McCrae 2011, Kennedy 2014) making it difficult to create research and innovation based industries in which invention through science is central to economic amelioration (Drudy 2011).

1.3 Science and Physics Education: The Problem of Static Student Numbers

The previous writing gave an insight into the perceived problem of static and sometimes declining student numbers in science and physics, giving cause for international disquiet (Lyons 2006). One of the core reasons for declining student participation is that of a widespread decrease in interest and engagement throughout science education (Logan and Skamp 2013, Mujtaba and Reiss 2014, Watkins and Mazur 2013). International research indicates that as an individual progresses through adolescence, they become less interested (Hidi and Harackiewicz 2000, Watkins and Mazur 2013, Wigfield and Eccles 1992) and engaged (Park *et al.* 2009) with science. As a pupil enters secondary school, they envisage working in a real science lab with a specialist teacher. What is presented to the pupil at this time is pivotal in shaping their image of science (Swarat *et al.* 2012). As the first year progresses, it has been shown that more negative feelings toward science start to emerge (Darby 2005). This is reiterated by a number of other authors who indicate that the start of secondary schooling marks the point in which scientific interests decline (Archer *et al.* 2010, Barmby *et al.* 2008, Swarat *et al.* 2012, Tytler 2007, Walper *et al.* 2014). Such feelings are to be put in context, as attitudes to all subjects decline and become more specialised (Feist 2006), but for science (Breakwell and Beardsell 1992) and especially physics (Häussler and Hoffmann 2002) it seems to be particularly rapid and acute.

Within the literature, there are various reasons for the decline in interest and engagement including; the perceived image of science (Jidesjö *et al.* 2012, Kessels *et al.* 2006,

Osborne *et al.* 2003, Lyons 2006) and physics being difficult (Angell *et al.* 2004, Hoffmann 2002), un-relatable content (Barmby *et al.* 2008, Lyons 2006, Osborne *et al.* 2003), unattractive career paths (Sjöberg and Schreiner 2010, Subotnik *et al.* 2009) issues with self-image (Bennett and Hogarth 2009, Kessels *et al.* 2006) and transmissive pedagogies (Jidesjö *et al.* 2012, Logan and Skamp 2013).

Although there is a diversity of explanations as to the decreasing student numbers in science, various theoretical and methodological foci present pedagogy as the largest determinant of interest and engagement in education (Hampden-Thompson and Bennett 2013, Jidesjö *et al.* 2012, Logan and Skamp 2013, Willingale-Theune *et al.* 2009). Watkins and Mazur (2013, p. 39) state that “a single positive interaction, excitement about a courses teaching and/or content cause a student to confirm his or her choice”. Hence, placing instructional practices at the centre of the conversation in terms of generating interest and engagement to impact positively on future subject choices. As stated by Maltese and Tai (2011), the majority of students who decide to study STEM subjects in the future, do so during their secondary schooling and that choice is related to interest.

Educational reform is warranted if the projected focus is on developing interests and engagement in science (Christidou 2011, Tytler 2007). Curriculum and classroom practices are failing to excite and ignite interest (Tytler 2007) and, as noted, this may be due to an emphasis on didactic pedagogies (Jidesjö *et al.* 2012, Logan and Skamp 2013). The development of a talent pool in STEM depends on pedagogy with a focus on sustaining pupil interest as students who develop an interest in STEM are more likely to pursue a career in the area (Subotnik *et al.* 2009). In 2011, the Wellcome Trust published a report on science education in Britain. One of the key findings of the report was the need to make science education interesting and fun to promote engagement (WellcomeTrust 2011). Tai (2006) demonstrated a relationship between eighth grade students’ interest in science, and the completion of college majors in physical sciences, particularly if the students came from an expert instructional background (Subotnik *et al.* 2009). According to Lavonen *et al.* (2005, p. 72) “pupils will study and learn physics better and, moreover, choose physics courses in upper secondary school if they are interested in it.” Interest is a pivotal concept when trying to negotiate the relationship between learning and motivation. It is not only an educational means, but an end in itself (Lavonen *et al.* 2005). The development of interest among students is at the vanguard of excellent teaching (Hoffmann 2002). However, Dohn (2013, p. 2734) speculates, “how to catch students’ interest and hold it for a prolonged time?”

1.4 Physics Video Hooks: A novel approach to increasing Attention, Interest and Engagement

“It is somewhat surprising that so little work has been done in the context of science classrooms to identify what are the nature and style of teaching and activities that engage students” (Osborne et al. 2003, p. 1074).

The focus of this research is to investigate the use of novel, video based physics hooks and how they can be both designed and incorporated into classrooms to target the constructs of attention, interest and engagement among the student body. The goal is to interleave technology based design, in the form of digital video with pedagogy, in a naturalistic context. The aim is to evaluate and progress the hook, a digital-physical artefact, from both practical and theoretical orientations. The focus will be on marrying the theory and design that informs the hooks. The research asks, how can you design and implement digital video so that it specifically develops attention, interest and engagement among science students? Thus, as core features of this research; educational technology, video and hooks will be examined separately as part of this chapter. Their role in improving levels of attention, interest and engagement will be delineated, giving the reader an insight into why the three are combined to form the novel ‘video hook’ educational technology based approach being advocated and developed by this research.

1.4.1 Hooks

The best teachers, speakers and entertainers know how to prepare an audience (Riendeau 2013). In fact, today, most performers have warm up acts to engage the audience for the following entertainment. Teachers have no such luxuries, but can use other methods before instruction begins. The methods in question are called ‘hooks’. Hooks represent an instructional method used at the beginning of class to grab attention (Hunter 1994, Lemov 2010, McCauley *et al.* 2016) foster interest (Jewett Jr 2013, Marinchech 2013) and create engagement (McCrorry 2011, Riendeau 2013). Coffman (2003, p. 2) asks “Wouldn’t it be great if our students came to class prepared – not just having read the assignment, but mentally prepared as well – alert and ready to debate, challenge, interact, and contribute?” In reality, this is rarely the case. However, it is advised that instructors make use of the time before the class begins to hook students’ attention and concentration (Coffman 2003). Bergin (1999, p. 87) refers to “catching the interest of students” as pivotal for learning and engagement. Teachers have a limited opportunity to engage (Coffman, 2003). Students are most attentive during the first ten minutes of class, so using this time correctly is imperative for maintained and continued levels of attention, interest and engagement. When this is lost, the quality of learning can be diminished

(Darby 2005). Hooks serve as an enticement for learning (Lemov 2010). It is argued that they are pivotal in education as numerous authors note how engaging the student from passive to interactive positions is the first step to deeper learning (Beeland 2002, Clifton and Mann 2011, Osborne and Dillon 2008, Patrick *et al.* 2000). Generally, a hook is seen as a short introductory moment that puts the material out in front. The hook constitutes the start and not the whole lesson (Marincheck 2013). For a hook to be successful, it has to be short and it has to be posed at beginning of class (Lemov 2010) Introducing the material in a way that is inspirational gets pupils to take the first steps willingly. The best hooks take the most interesting and engaging aspects of a topic and show them off (Lemov 2010).

1.4.2 Educational Technology

As information technology grows, it provides incremental learning environments that give rise to new areas for research. Learning enhanced by technology is continually garnering momentum with competition from knowledge based economies driven by the need for effectively trained employees with the ability to rapidly adopt new skills (Zhang *et al.* 2006). Within this remit, educational technologies are seen as a way of improving modern instruction (Amiel and Reeves 2008). Educational technology does not seek to replace established methods in education, (ASTI 2013b) rather, educational innovation through technology is becoming a key priority for education (Bocconi *et al.* 2013).

The argument is put forward by the researcher that educational technology based hook pedagogies are a salient way of developing the aforementioned hook constructs among students. According to Guzey and Roehrig (2012, p. 163), “The use of learning technologies in science classrooms has also been shown to increase students’ attention, engagement, and interest in science”. Such sentiments are echoed by Tan and Pierce (2012) who suggest the use of multimedia as an icebreaker for initiating classes. The models and roles of multimedia in science education has gained theoretical and practical weight due to two trends. The first is the emphasis on teaching about the processes and nature of science (Gilbert 2005). The second is the readily available amount of technology present in society that is permeating into classrooms (Gilbert 2005, Mariooryad *et al.* 2014).

Due to this, technology was positioned as a requirement to be folded into the hook design, in terms of its perceived ability to support the three constructs of attention, interest and engagement; and also its rapid influx into the classroom, with a view to improving the learning experience. However, the quandary remained as to what kind of technology would be used as the hook medium. To ensure complete technological integration of hooks, the choice of an

appropriate educational technology platform was pivotal. The selection of an appropriate educational technology focused on the two users in the classroom, teachers and students. With regard to teachers, numerous authors speak to the difficulty of integrating technology into the classroom (Awan 2012, Bingimlas 2009, Law 2009). Therefore, the hook approach needed to be simple and easily integrated into the fabric of a typical class. The prominent quandary in terms of students is their label as ‘digital residents’ (Connaway *et al.* 2011, White and Le Cornu 2011). They are deemed to be comfortable with technology and a platform was required that would directly appeal to today’s cohort of pupils (Duffy 2007). Given this remit, the hooks were constructed in a digital video format. Based on the aforementioned user needs, it is posited that video is readily recognisable to both students and teachers, while also being relatively easy to integrate into the classroom context. Further justification behind this decision will be explored presently.

1.4.3 Digital Video

Video is at the vanguard of educational technology (Sykes 2012). Educational technologies are vast, however, Zhang *et al.* (2006) suggests that video is one of the most powerful mediums with the most potential to change modern education. The use of web-based video in science teaching is becoming commonplace (Pace and Jones 2009) and in the classroom, YouTube has become an omnipresent educational tool used to enhance learning (Jones and Cuthrell 2011). This in turn has led to increased interest into teaching and learning with video (Jones and Cuthrell 2011). Today, video ubiquitously permeates throughout every aspect of life. Among the benefits of modern technology, video streaming offers considerable advantages for educators and learners alike (Fill and Ottewill 2006). Internet related infrastructure is becoming cheaper and more powerful with educational institutions seeking more relative video content on a daily basis (Sykes 2012). In the midst of such a cultural shift, education has become more open to its use in the classroom (Bell and Bull 2010). Video is not new (Berk 2009), however, advances in Wi-Fi and internet speeds has resulted in a novel, instantaneous and powerful learning system (Zhang *et al.* 2006).

Educational video, a subsection of educational multimedia, has received increased attention due to its ability to present context in a dynamic fashion by use of images, audio, text and animation (Mayer and Moreno 2003). Video has been a staple of instruction for years in many branches of education as it provides for a narrative visualisation that is dynamic, making it a powerful medium for learning (Shephard 2003). Berk (2009) describes a teaching scenario in which a teacher darkens a classroom. As students attempt to anticipate what is happening,

the teacher plays a video clip. The author describes this as a “fireball stimulus package” for new topics with a huge impact that completely grabs student attention and interest (Berk, 2009, p. 11). Numerous authors reiterate that video can be a powerful medium when used at the start of class (Ljubojevic *et al.* 2014, Steffes and Duverger 2012, Tan and Pearce 2012) which aligns with the suggested pedagogical usage of hooks.

In terms of hook ‘theory’ and the constructs of attention, interest and engagement, Berk (2009, p. 2) outlines 20 specific learning outcomes for teaching with video clips. One and three are “Grab students’ attention” and “Generate interest in class” respectively. Schwartz and Hartman (2007) add to this and note that video can be used as a trigger for engagement. Steffes and Duverger (2012) extol that video captures student attention and interest and thus augments the retention of academic content. This evidence suggests that video has the potential to be an excellent hook medium. Thus, it was chosen and carried forward into the hook development stage which will be described in the next section.

1.4.4 Science Education Resource (SER) design team – Hook development

The physics video hook development takes from the various theoretical positions on hooks, educational technology and digital video and combines them in a singular form. The specific purpose of the physics video hooks is to increase attention, interest and engagement in physics. This section will give a brief overview of the hook development process (for a complete breakdown of the design and build process, see Chapter 3: Physics Video Hook Design Framework).

The purpose of the Science Education Resource (SER) design team was to design and construct an instructional resource that would act as an effective hook when applied to science classrooms with second level students (11 – 15 years). This was a collaborative design project conducted in 2012 with pre-service science teachers and educators at the National University of Ireland, Galway (NUI Galway). As part of this project, six pre-service science teachers were recruited to work with a science and technology educator. Working in separate pairs, the goal was to design a suite of physics, chemistry and biology video hooks. The development of the hooks took place over the course of eight weeks. Videos were based on a series of relevant topics from the Irish junior science curriculum. They offer science teachers a collection of resources that capture novel and engaging aspects of syllabus based science topics.

The researcher worked with another teacher on the creation of the physics hooks as part of the SER design team. Progressing through the various phases of the project and working in

collaboration with other teachers, gave the researcher the impetus to pursue further work and research in this area.

1.5 Biographical Motivation

“Most teachers instinctively seem to recognise the need to interest their pupils in the classroom, yet they often complain that the [...] assessment-driven classrooms will always take precedence over the need for any longer-term affective outcomes” (McCrorry, 2011, p. 94).

The personal and professional development of the researcher has had a significant impact on why and how this study was conducted. Throughout my secondary education, I always had an interest in science, in particular physics and biology. At this time, I realised that physics is the central science with chemistry and biology being complicated offshoots. Hence, I believe that an understanding of physics allows a student to scientifically appraise any endeavour with a logical understanding of the surrounding world due to its alignment with critical thinking.

Before returning to university to undertake this investigation, I qualified as, and worked as, a secondary science teacher, specialising in biology as per my primary degree and Master’s. Within schools, I noticed an obvious schism between the number of students studying biology and the number studying physics. This gap first became apparent when teaching general science, which is separated into the aforementioned three core sciences. My students had preconceived notions of physics as being uninteresting and difficult when compared to the other sciences even though they had received no physics instruction.

It was at this time that I was hired to work for the SER design team in NUI Galway. The project set out to create a suite of video hooks with the primary objective of augmenting student attention, interest and engagement in the sciences. Based on my experiences, I opted to work on the physics team. On a personal level, this process illuminated exactly how interesting and exciting physics can be. As the core science, it has the potential to demonstrate fundamental phenomena through video more so than the other sciences and spark curiosity in a host of areas. It became apparent that such a resource could become part of a teacher’s tool kit to ameliorate the aforementioned issues within modern physics.

Through working in collaboration with other teachers, I also noted how, time constraints within teaching was a severely limiting factor in terms of designing hooks and other resources to stimulate interest in the sciences. It also became apparent how many video

resources lack proper design and are not grounded in the classroom context. From both a theoretical and practical perspective, I realised the role design, technology and pedagogy combined could play in impacting upon students in a positive manner.

This work inspired the researcher to examine fields of educational technology, design-based approaches to technologies and the pedagogical methodologies of implementing hooks through a digital video based medium, all of which have played pivotal roles both empirically and theoretically in the development of this thesis.

1.6 Research Questions

The research addresses a primary research question which can be broken down into subsidiary questions. The primary research question is: How can physics video hooks be designed and implemented to generate student attention, interest and engagement in physics?

The supporting question which helps answer the primary question has two parts: (a) Does teaching with video hooks have the potential to target junior science students' attention, interest and engagement in physics lessons? And (b), if so: what are the integral components of physics video hooks from both technological and pedagogical design perspectives that shape the development of student attention, interest and engagement?

With these questions, the thesis endeavours to delineate the characteristics of successful video hook design and utilisation by teachers in naturalistic contexts.

1.7 Outline of Chapters

The structure of thesis is set out to represent how the research evolved over the course of the four years. Chapter one, describes the rationale to the research, the guiding research questions and the biographical motivation of the researcher.

Chapter two is the review of the literature, which investigates the extant literature and draws from a number of diverse domains relevant to the research project. A thorough and comprehensive examination of hooks is incorporated, with an assessment of hook strategies and their historical role in instructional models. In addition, a review of the Irish educational system with a particular emphasis on Junior Certificate science, along with the new Junior Certificate curriculum provides an insight into the naturalistic context in which the study takes place. As per the focus of video based hooks, the chapter finishes with a review of video and technology based classroom interventions.

Having delineated the methodological requirements and justifications, Chapter three articulates the theoretical framework that guided empirical assessments. It is wholly derived from pertinent literature. The chapter incorporates the cognitive and affective constructs that summarise the intended impact of hooks on the student body.

Chapter four introduces the design artefact, the prototype ‘physics video hook’. This section outlines the development of the video hook design and what theoretical positions and strategies were embedded into the hook design. It also demarcates the initial pedagogical design. The prototypes design as a whole informs the future cyclical iterations.

Following this, and informed from the previous chapters is Chapter five, which describes the methodological approaches used throughout the research. The project follows a Design-Based Research (DBR) methodological paradigm. Within such a framework, three phases of research are conducted with varying research methods including interviews, observations, researcher reflections, teacher journals, qualitative questionnaires and group interviews. DBR is particularly suited to the project as the research attempts to marry theoretical foundations of hooks, with technological design in a real-world practice based environment through reflexive capacities. The iterative phases allow for the development of an emergent prototype design theory that incorporates hook pedagogy and design while being grounded in data.

Chapter six discusses the first design cycle or the pilot phase to the project. This is the first iteration with the aforementioned prototype design. As such, it provides the context that feeds into the following design cycle. Chapter seven, references the second iteration or the mainstreaming phase. This cycle is informed by the first and is larger in terms of participants and scope. The final design iteration is illustrated in Chapter eight. This is the capstone phase and was informed by the previous two phases. It produces the final prototype theory that is explored in the final chapter.

Chapter nine is the findings and conclusion chapter. This communicates the rigorous design process and design guidelines, which are the main contribution of the research. Other substantial contributions are also outlined. Chapter nine is concluded with recommendations for future research. A summary of the research gaps, research questions, methods and analysis are presented in Table 1.1.

Table 1.1: Overview of research gaps, methods and analysis

Research Gaps	Research Question (RQ) and Research Objectives (RO)	Method	Objectives	Analysis
Little to no understanding with regard to how video can be designed and implemented as a hook in teaching. Research into teaching with video is also lacking.	RQ: How can physics video hooks be designed and implemented to generate student attention, interest and engagement in physics? (a) Does teaching with video hooks target junior science students' attention, interest and engagement in physics lessons? And (b), if so: what are the integral components of physics video hooks from both technological and pedagogical design perspectives that shape the development of student attention, interest and engagement?	Design-Based Research, qualitative intervention	To investigate how video hooks are used in a real classroom environment and identify their impact if any.	Analytical memos, Coding Thematic analysis Reflection
Lack of understanding as to whether the hook method can be applied to video.	RO 1: To analyse how secondary science teachers use physics video hooks from both a teaching and learning perspective.	Observations, Interviews, Journals, Group Interviews, Qualitative surveys	To identify the best way(s) to implement video hooks in the junior science classroom.	Analytical memos, Coding Thematic analysis Reflection
Little to no research into the impact of physics video hooks on students.	RO 2: To establish if physics video hooks are effective in their primary purpose of targeting the affective and cognitive states of attention, interest and engagement among junior science students.	Observations, Interviews, Journals, Group Interviews, Qualitative surveys	To understand how hook videos impact students' cognitive and affective states, if at all.	Analytical memos, Coding Thematic analysis Reflection
Little to no research into the various ways a video hook can be used in the classroom.	RO 3: To determine if physics video hooks have ancillary applications within the junior science classroom.	Observations, Interviews, Journals, Group Interviews, Qualitative surveys	To identify the variety of instructional techniques that can accompany hook videos.	Analytical memos, Coding Thematic analysis Reflection
Little to no research on the design of video hooks.	RO 4: To delineate the specific design elements that should be included and excluded in physics hook development.	Lit. Review, Observations, Interviews, Journals, Group Interviews, Qualitative surveys	To identify the successful and unsuccessful elements of hook design.	Analytical memos, Coding Thematic analysis Reflection
Lack of guidance and understanding with regard to both implementation and design of hooks.	RO 5: To create a theoretical and design framework for physics video hooks.	Lit. review, Observations, Interviews, Journals, Group Interviews, Qualitative surveys	To understand and disseminate the various processes involved in both teaching with and designing hooks.	N/A

1.7.1 Ethical Considerations

All ethical considerations within this research have been made with constant consultation with World Health Organisation (WHO) ethical guidelines and the British Educational Research Association (BERA 2011) ethical standards.

Participants in this study comprise of a wide variety of people. They include teachers, students, parents/guardians and other school staff. All research participants have been made fully aware of the purposes, risks and potential reward of the research (Cohen *et al.* 2011, Gall *et al.* 2007). The video hooks are non-controversial and do not represent a threat to any participants. The video hooks are of various scientific phenomena and can be viewed online at <http://www.sciencehooks.scoilnet.ie/> or at <http://tinyurl.com/physicshooks>.

Working with teachers and students formed the bulk of this research. Meetings were held with every participating teacher along with class groups, associated principals and stakeholders to fully delineate the details of the study. Informed consent and informed assent (where appropriate) was sought for all participants including parental consent for students. Verbal consent was continually sought throughout the course of the investigation. As noted previously, methods of data collection include interviews, observations, group interviews, qualitative questionnaires teacher records and a researcher reflective journal. All participants took part freely and voluntarily with the right to comfortably withdraw without penalty. Rights to privacy and confidentiality were honoured and will continue to be honoured.

Regarding the maintenance of privacy and confidentiality, participants were informed of those (researcher and supervisor only) who will have access to their information and no unauthorised person will have access to data. Pseudonyms, codes and numbers were used to mark responses and identities.

Data will be kept up until five years after the successful submission of the PhD as agreed by related examiners for the verification of findings. Complete data will be stored on an external hard drive and deposited in a locked drawer in Dr. Veronica McCauley's office, GO19, CIMRU, Nuns Island, Galway City, Co. Galway. Data will be wiped from all electronic sources. Physical data will be shredded and disposed. No data will be sent via email or stored in online databank services.

1.8 Chapter Summary

This chapter has introduced and established the context in which the research study is situated, while also setting out key research questions and the issues from which they are framed. It has examined the vital role science and physics play in modern society from multiple perspectives. As such, it has introduced the challenges that face western nations in terms of decreasing number of students opting to study the physical sciences from secondary education onwards with a particular focus on the Irish context. It is contended that an apparent decline in interest and engagement are some of the core reasoning's for this occurrence. Recognisant of this, a new approach to increasing the three constructs of attention, interest and engagement, as per theory, is proposed, namely video hooks.

This chapter also alludes to the various justifications as to why this research study's potential is of significant value. Firstly, the thesis has the potential to create practical and theoretical hook guidelines to augment attention, interest and engagement in physics that will potentially be transferable to other subjects. Secondly, the study examines educational technology with digital video at its core. The study has the potential to add to extant knowledge in terms of how to teach with video. Moreover, and less commonly noted in the literature are details on how to create and design video for specific teaching and learning purposes. Thirdly, the study will make a distinct contribution to knowledge in the understanding of hooks in numerous contexts including pedagogy, design and impact, all of which are areas whereby little to no research has occurred.

This will be highlighted in the following chapter, the review of the literature, drawn from diverse domains, it is wholly pertinent to the study.

Chapter 2: Literature Review

2.1 Chapter Introduction

In the introductory chapter, the researcher detailed the current state of affairs pertaining to the number of students choosing to study science and physics. It was postulated that such trends are concomitant with levels of student interest and engagement in said subjects. This chapter will build on this idea and provide further insight into the determinants of student interest and engagement in class. In addition, the following will provide a grounding for science education in Ireland as all data will be derived from the Irish classroom context. With this, the chapter will introduce and establish ‘hooks’, a teaching methodology that specifically targets students’ attention, interest and engagement. Hooks will be illuminated through an exhaustive review of the extant research literature. With such an elucidation, this chapter will attend to the innovativeness of this doctoral thesis as the first substantive study of hook implementation in secondary science education.

2.2 Science and Physics in Ireland

As was demarcated in the first chapter, internationally, concern is growing over continual declines and static student numbers in STEM (Logan and Skamp 2013, Mujtaba and Reiss 2014, Watkins and Mazur 2013) and the associated negative economic (DeBoer 2011, Hampden-Thompson and Bennett 2013, Ruiz *et al.* 2014) and societal (Jidesjö *et al.* 2012, Sadler and Zeidler 2009) impacts of such trends. Given this, investigations into pupil’s attitudes and views of science have become commonplace in educational realms (Osborne *et al.* 2003). This research follows a similar vein of inquiry, however, being completely embedded within the Irish context, science education in Ireland will be explored to provide an adequate frame of reference for further investigation.

In Ireland, science in the secondary school system is not a compulsory subject. Yet, on an annual basis approximately 90% of Junior Certificate (11-15 year olds) candidates choose to study science (DES 2017). In the Leaving Certificate course however (15-19 year olds), the range of scientific subjects diversifies with biology, chemistry, physics, physics and chemistry and agricultural science (State Examinations Commission 2013). At the precipice between junior science and the broader range of Leaving Certificate subjects, students have to specialise. With such a narrowing, a repeated trend in Ireland is the vast majority of students opting for life sciences as opposed to the physical counterpart (Figure 2.1). Biology is an exceedingly popular subject, while the numbers in physics remain low by comparison (CSO 2017). Given the aforementioned

economic concerns pertaining to STEM graduates, the numbers studying physics represents one of the salient quandaries in Irish science education (DES 2004, Drudy 2011). As can be seen in figure 1, the disparity between physics and biology is an established schism (Kennedy 2014).

Given this, Irish science education replicates international trends pertaining to student subject preference. When examining the rationale behind such tendencies, both Matthews (2007) (ROSE Project) and Regan and Childs (2003) determined that Irish students demonstrate a distinct lack of interest in physics and technical aspects of science. It was found that students prefer topics that are visual and relevant to their lives. This result is consistent with numerous international studies that place interest and engagement as the central features around which subject choices revolve (Hulleman and Harackiewicz 2009, Watkins and Mazur 2013). This was noted in the introductory chapter, but will be further examined in the following section.

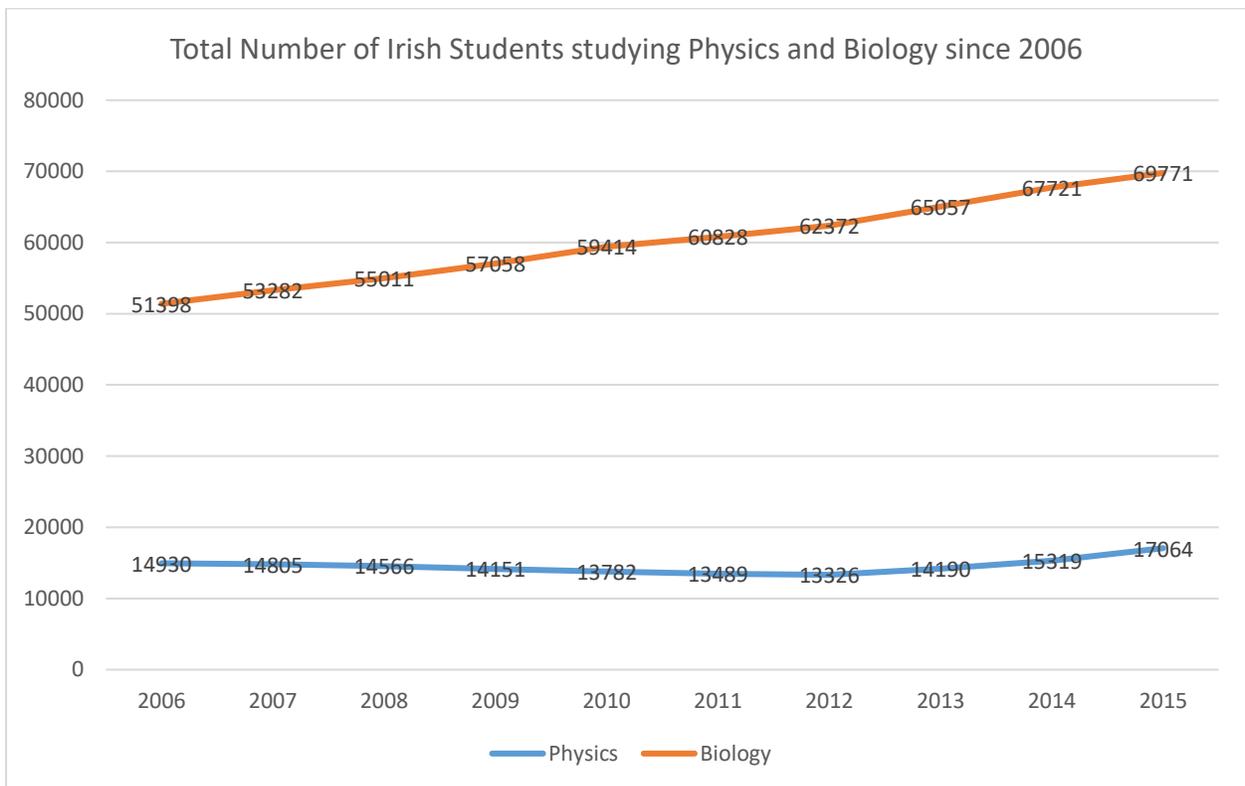


Figure 2.1: Total number of student studying physics and biology in Ireland (DES 2017 accessed online 2017)

2.3 Interest and Engagement as Core Educational Constructs

Within the wider literature, the creation of interest (Krapp 2007) and engagement (Sinatra *et al.* 2015) are recognised as a superordinate aim of educational endeavours. Within this thesis, interest is defined in terms of the four-phase model of interest development encompassing situational and individual elements (Hidi and Renninger 2006). Engagement is defined under the tripartite definition including cognitive, behavioural and emotional components (Fredricks *et al.* 2004, Fredricks and McColskey 2012, Hampden-Thompson and Bennett 2013). Further exploration of these constructs will be realised in Chapter 4. Their importance as educational goals, is at the forefront of progressive educational environments (Joseph and Nacu 2003) as a powerful influence on learning (Ainley and Ainley 2011, Hidi and Renninger 2006, Krapp 2002) and further, subject choice. Numerous authors posit that one of the core reasons for students not opting to study science and physics is that of a widespread decrease in interest and engagement (Logan and Skamp 2013, Mujtaba and Reiss 2014, Watkins and Mazur 2013). Hulleman and Harackiewicz (2009) state that interest is one of the most powerful indicators of future subject choice, while Park *et al.* (2009) discusses how a lack of engagement in science may be detrimental to a student's willingness to partake in further science courses.

Such declines in engagement and interest in science and physics are commonplace across developed nations. Throughout the literature, numerous justifications are presented including; unrelatable subject content matter (Barmby *et al.* 2008, Lyons 2006, Osborne *et al.* 2003), perceived unattractive career paths devoid of social interaction (Sjøberg and Schreiner 2010, Subotnik *et al.* 2009), science as a challenging subject (Jidesjö *et al.* 2012, Kessels *et al.* 2006, Lyons 2006, Osborne *et al.* 2003) in particular physics (Angell *et al.* 2004, Hoffmann 2002) and how choosing to study the science frames one's self-image (Bennett and Hogarth 2009, Christidou 2011, Kessels *et al.* 2006). As can be noted, the lack of interest and engagement in science education is an intensely researched phenomenon, however, the most commonly cited reason for a decline in the former constructs is that of instructional practices (Maltese and Tai 2011, Tseng *et al.* 2013, Watkins and Mazur 2013).

Tytler (2007, p. 2) notes a “deep seated disenchantment” between science and pedagogy. The author, among others, paints scientific instruction as being dominated by conduit metaphor (Osborne and Dillon 2008). Moreover, Hong *et al.* (2014, p. 110) states that “science classes today are primarily didactic, lacking opportunities for students to explore”. Given these sentiments,

contemporary pedagogy in science is seen to reside in a transmissive domain, making it less engaging than other subjects (Hampden-Thompson and Bennett 2013, Willingale-Theune *et al.* 2009). The transmissive view of teaching implies that the teacher's role is that of a communicator of knowledge. They explain solutions, and ensure studious concentration in the classroom (Drudy 2011). In 2006, Lyons conducted a meta-assimilation of data from countries including Sweden, England and Australia. The author discovered a congruence between students' lacklustre attitudes toward science and transmissive pedagogical practice. Students described their teaching as information originating from an expert source, trickling down to passive recipients. Indeed, the theme of transmissive pedagogy was so widely reported that students regarded it as inherent in their science education (Lyons 2006). Indeed, physics as a subject, has a reputation for being taught in a lacklustre pedagogical style (Chandra and Watters 2012, Lasry *et al.* 2009).

McCauley *et al.* (2015) postulate that the dominance of transmissive techniques is grounded in the weight of assessment driven curricula, which from a time and resource standpoint, often limit opportunities to focus on student interest and engagement in class. This is reinforced by McCrory (2011, p. 94) who states that "assessment-driven classrooms will always take precedence over the need for any longer-term affective outcomes". Logan and Skamp (2013) state that transmissive pedagogies do not lead to the development of situational interest except for the intellectual elite. Moreover, Martin *et al.* (2015) posits that teachers are under extreme time constraints, which restricts instructional exploration. Indeed, in recognition of the pervasiveness of transmissive pedagogies, more active and student centred pedagogies are advocated (Tranter 2004, Young *et al.* 2009). Yet, at second level in Ireland, the transition from transmissive models to student centred ones is proving difficult. While there has been some movement, traditional subject divisions and terminal exams restrict innovation and change (Drudy 2011).

Certainly, this presents a scenario in which instructional approaches utilised by science teachers can be limited due to a plethora of restrictions and immediate pedagogical needs. Thus, placing limits on instructional variation and more active teaching methods, those most associated with affective outcomes such as interest and engagement. The presence of the two constructs among the student body are greatly determined by a teacher's pedagogy (Henriksen *et al.* 2015). Hence, efforts to reform science education must take note of the key role of interest and engagement in relation to subject choice, while also taking into account the modern and ever evolving context in which teacher's work (An and Reigeluth 2011).

Based on such sentiments, the researcher advocates a teaching strategy/resource that augments interest and engagement in class, while also accommodating the praxis of modern science teaching. With such a remit, this research is investigating hooks. Hooks are short introductory pedagogical strategies utilised to generate attention, interest and engagement in class. They have the capacity to bring about change in educational environs as interest and engagement are malleable and determined by immediate instruction (Harris 2011, Klassen and Klassen 2014, Palmer 2009, Wefald and Downey 2009). As such, hooks can be ‘injected’ into pedagogical schedules to benefit both students and teachers. At present, research into hooks and hooking strategies is limited. However, they may have the potential to benefit science instruction and science education rendering them wholly appropriate for further investigation.

2.4 Hooks – An Introduction

“Five minutes before the end of a lesson, students may be waiting impatiently for the bell to ring or be so engaged in the lesson that they are quite unaware of the time” (Tsai et al. 2008, p. 480).

Based on the contemporary landscape of science education as portrayed by the reviewed literature, hooks as an educational tool have the capacity to become a staple of teachers’ repertoires (Lemov 2010). Through an assimilation of the literature, a hook can be defined as a short instructional method or resource employed during the lesson introduction to augment the constructs of attention (Hunter 1994, Lemov 2010, McCauley et al. 2015), interest (Jewett Jr 2013, Marinchech 2013) and engagement (McCrorry 2011, Riendeau 2013) among students. With such a definition, they have the potential to bring about behavioural benefits, combat boredom and augment learning (Lemov 2010). This is pivotal in education as authors note how students must traverse from passive to interactive positions to enable deeper learning (Beeland 2002, Clifton and Mann 2011). The following will demarcate the development of hooks, initially occurring as a ‘hook-like’ phase throughout numerous instructional approaches to the advent of hooks as a clearly defined instructional method.

2.4.1 Historical Development

The ideology behind using a hook at the start of class is not new. The theory, to the researcher’s knowledge, has existed for over one hundred years. However, the teaching method has been described under a number of guises and labels with ‘hook’, inspired by hooking an audience (Riendeau 2013), being the most modern terminology. Herbart in 1901 was the first to note that

subject interest is the first principal of effective instruction (Herbart 1901). The author capitalises on interest by initiating instruction with students discussing their experiences of the natural world. By allowing students to bring their prior experiences into the classroom, the lesson content becomes more meaningful and personal. Within Herbart's instructional model, this type of introduction was known as the preparation phase.

Dewey was the next author to mention a hook-like phase of instruction in 1933, in terms of developing interest at the beginning of instruction. Previous to this in 1913, Dewey was the first to identify the vital role that interest plays in learning. He believed that for deep learning to occur, interest must be present in the classroom environment. He also believed that interest could be fostered (Dewey 1913). Based on Dewey's work an instructional model has been developed in which the first phase is entitled 'Sensing Perplexing Situations' (Dewey 1933). It is explained as the teacher presenting an experience whereby students feel frustrated and curious through the examination of a problem. As mentioned, this hook-like phase was part of an overall instructional model. Indeed more hook-like phases were developed with Heiss *et al.* (1950) and Atkin and Karplus (1962). Again, these were a small part of an overarching approach to teaching. As with many of these models, however, the authors simply advocate a hooking based strategy and do not provide in-depth descriptions of methods or give examples. The 5E instructional model represents the first instance in which descriptors of the hook like phase, in this instance 'engagement', begin to appear. The model will be articulated presently.

2.4.2 5E Model

The 5E model stands for Engagement, Exploration, Explanation, Elaboration and Evaluation. The model was developed by the BSCS (Biological Sciences Curriculum Study) in the 1980s (Bybee *et al.* 2006). As mentioned, the first part of the 5E instructional model is engagement. Positioned at the start of class, it is noted that any engagement based activity should be short and simple. It is postulated that this activity should assess the learner's prior knowledge and build connections between what they know and what they need to learn (Bybee 2009). More recently, the 5E model has been employed by the Teaching Enquiry with Mysteries Incorporated (TEMI) project. In terms of the first E, engagement, TEMI employs mysteries in class as a hook (Broggy *et al.* 2014, Dittmar *et al.* 2014). Broggy *et al.* (2014, p. 3) states "Unless students are engaged and motivated, and have their curiosity aroused so that they start asking questions: 'Why? How? What if?', then there will

be no real enquiry.” Hence, mysteries are utilised as a motivator for students in class. Dittmar *et al.* (2014, p. 2307) describes this impact as a “want to know” feeling among students.

Although the first phase of the 5E model can be aligned in part to a hook methodology, as it aims to engage students through an instructional event, the focus of research pertaining to TEMI and other work is not strictly related to engagement. The publications take a holistic approach to ‘enquiry’ in class. The TEMI project has assimilated and is currently disseminating various mysteries and enquiry approaches generated by teachers. However, their primary focus is on the entire model as opposed to just the hook like phase of engagement.

Similarly, the next hook-like phase to appear is that of Keller’s (1984) Attention, Relevance, Confidence and Satisfaction (ARCS) model in which the first step Attention, as the name suggests, specifically attempts to gain the attention of students for the following instruction. Similar to the 5E approach, the first step is not the distinct focus of investigation, rather part of a more generalised approach. It will be examined in the following section.

2.4.3 ARCS Model

The ARCS model, as developed by Keller (1984, 1987a, 2000), presents four general requirements to inspire motivation. It is designed to be a practical strategy with the first ‘hook like’ goal being to obtain and sustain student attention. The attention step is denoted as a warm-up activity by the author to develop knowledge seeking behaviours among students (Keller 1987). The author notes that before attention can be directed, it must first be acquired. It is postulated that getting attention is not that difficult and a number of ‘attention-getting strategies’ are presented (Keller 1987a). In the case of perpetual arousal, any sudden unexpected event such as a change in voice or surprising information will activate a person’s attention (Keller 1987a). In sustaining attention, a deeper level of curiosity needs to be activated with an end result of knowledge seeking behaviour (Keller 1987b). Keller’s work continued in 2000, when the author highlighted the challenge educators face in continually trying to stimulate learners. Through a further examination of the ARCS model, Keller (2000, p. 2) suggests that a teacher can gain attention by creating unexpected events; “... a loud whistle, an upside-down word in a visual”. Yet, for a deeper level of engagement, mentally stimulating problems can be employed to trigger curiosity (Keller 2000). In 2004, Keller and Suzuki posit that technology, with new innovative features has the potential to make instruction more appealing to learners. In terms of gaining attention via technology, a variety of tactics must

be employed such as animations or incongruity (Keller and Suzuki 2004). Similar to the techniques utilised in the TEMI project, higher levels of curiosity can be attained by using mysteries to stimulate a sense of inquiry in the learner. It can be derived from the work of Keller, that the author has expanded on the previous hook-like models to explicitly state the importance maintaining attention throughout instruction. However, scant advice is given for teachers looking to grab the attention of their students in line with the ARCS model. In concert, exemplars of hooks throughout the 'hook-like' phases described above are limited. Indeed, Anderman *et al.* (2004) posits that implicit in numerous motivational theories is the assumption that the student will pay attention. Such theoretical frameworks are widely advocated, yet, they do not explain how instructional activities initially grab a learner's attention (Anderman *et al.* 2004). This is the case with many of the formerly described instructional processes. They define hook like phases, but the research does not provide empirically refined methods for teachers to implement in their own classes. As such, there is a gap in the literature pertaining to the formal design and implementation of hooks in the classroom context. At this juncture, the literature takes a turn as the emergence of hook based writings begin to appear. This marks the division between hook-like phases in research and literature directly pertaining to hooks.

2.4.4 Hooks

The first formal investigations into hook instructional methodologies came about in the late 1960's. The following literature can be differentiated from the previous writing as it specifically focuses on hooks as opposed to a hook-like phase within a larger model. The first hook method, coined 'set induction', was spearheaded by Schuck (1969, 1970, 1981). and expanded upon by Perrot (1982). A set induction employs a formulaic introduction to a lesson by establishing a learning framework deliberately designed to facilitate links between learning and classroom experiences (Schuck 1981). Set inductions attempt to create an organising framework in lessons for a smooth transition from old knowledge to new. Given this, a set establishes the initial frame of reference to facilitate behavioural and cognitive goals and responses (Schuck 1970). According to Schuck (1970, p. 223) "a set is a cognitive process activated by a stimuli perceived by a person in an environmental situation". In light of this, sets are a powerful variable that can determine the pace of learning in the classroom.

Schuck (1970) provides an example of set induction with four main components, orientation, transition, operation and evaluation. The author describes an example situated in the

Chapter 2: Literature Review

biological process of photosynthesis. The set begins with orientation in which the teacher exhibits a bottle of milk for the purposes of generating a discussion on dairy and milk production. During transition, the teacher makes the analogy of a cow as a manufacturing plant that consumes raw material and through digestion makes two products, milk and manure. Next is the operation phase whereby the teacher introduces the new idea and makes the comparison between photosynthesis and the cow. In the photosynthetic process, the raw materials of water and carbon dioxide are processed by chlorophyll and sunlight to create the products, sugar and oxygen. The final phase is evaluation in which the teacher seeks comprehension by questioning students on the concepts discussed. Once the teacher is happy with the evaluation, they can move onto the body of the lesson.

As can be noted in the example, the hooking strategy is based upon relevance and analogies. Utilising this type of set, Schuck (1970) measured its impact on student achievement and retention. The author used a pre/post-test control group design. The findings indicated that when teachers incorporated set induction into their teaching, students made significant gains in achievement and retention. Teachers who used set induction were also perceived as being more effective than other teachers (Schuck 1970).

Schuck's work represents the first instance of empirical investigative efforts into the beginning of a class and how it can be framed to benefit student achievement and memory retention. With this, it can be argued that set induction provides the theoretical foundation for hooks. In resonance with the set induction literature, Hunter, in 1994, writes about anticipatory sets as a pedagogical strategy in which the teacher directs the student's thoughts toward the learning goals of a lesson. Anticipatory sets are defined as a short activity that garners attention at the start of a lesson. It may even be used as pupils enter a room (Hunter 1994). This marks the first instance within the literature that an author references a hook as being a short pedagogical event, utilised at the beginning of the lesson for the purposes of grabbing student attention. Through a synthesis of the modern literature, a hook can be defined as any type of short instructional method or resource (Marinchech 2013, Lemov 2010) employed during the lesson introduction (McCauley *et al.* 2015, Lemov 2010) to grab attention (Hunter 1994, Lemov 2010), foster interest (Jewett Jr 2013, Marinchech 2013, McCauley *et al.* 2015) and promote engagement (McCrary 2011, Riendeau 2013) among students. This definition is derived from the majority of hook literature,

Chapter 2: Literature Review

however, McCrory in (2011) advocates a slight variation on the above. The author posits that hooks should be employed throughout a lesson rather than just the introduction. However, at this point of research, the definition being employed is the former, as advocated by the majority of literature, which postulates that a hook is a pedagogical approach concomitant with the lesson introduction. A complete reference list with a brief description of both historical and modern references pertaining to hooks can be found in table 2.1 below.

Through the review of the literature, it has been determined that a persistent problem is the lack of formal interventions and empirical investigations testing the design and pedagogical implementation of hooks. More modern references simply advocate the use of hooks, yet give very few examples of classroom practice. One of the first to provide insight into hooks and their associated impact was McCrory in 2011. The author purports that there is a wide range of emotions that teachers can foster through their teaching to hook students. Curiosity, anticipation, uncertainty, surprise, understanding, wonder and amazement are components of good teaching that give students an emotional reward linked to the topic. McCrory (2011, p. 4) suggests, “throughout the lesson, teachers should either find or insert emotional hooks to grab and hold the attention of their students”.

In the same year, Zehr (2011) also describes another hook-related methodology in which links between science and public interest in pop culture icons and the scientific relevance of these icons are established to unobtrusively engage people in the subject. The widely recognisable image and impression of Batman can be related to many aspects of science, from his gadgets to his physical prowess (Zehr 2011). This is a relevance based hooking strategy as the content is widely known and has the potential to relate and be relevant to many students.

An example of using educational technology as a medium for hooks comes from Zavalani and Spahiu (2012). The authors applied virtual reality as a hook in engineering lessons. The approach is based on the idea of new technology promoting curious behaviour in class and operates on the basis of novelty and new experiences (Zavalani and Spahiu 2012).

The most extensive article in relation to classroom based practice is that of Jewett Jr (2013). Jewett Jr (2013), a physics teacher, finds that many students enter his classes with a fear of science. A fear that he tries to turn into interest. He aims to ‘hook’ students on every new topic so as to maintain interest for the rest of the academic term. A number of strategies are articulated. The first involves relating physics to everyday situations. Topics such as cooking, driving, eye tests and

social issues like global warming and the fuel economy are all grounded in basic physics. These social issues can provide the context for several weeks of study. The second hook instructional phase that is described is mysteries at the beginning of class to spark interest. Why is the sky blue? Why is the ocean blue? Are these two interconnected? Questions like these allow pupils to make their own inferences and connect concepts like polarisation, spectra and light. Similarly, Jewett Jr (2013, p. 442) mentions the use of magic at the start of class, “startling demonstrations can be used to raise student interest before moving onto the material”. Novelty is the final strategy used by Jewett Jr (2013). He incorporates antique devices such as hand powered vacuum cleaners into class. The machine illustrates basic physics principles at work. It can be used to connect with social history and students’ lives on a number of levels. Many pupils are fascinated as to what could be achieved before batteries and electricity. This technique is often performed with modern equipment modelled and tested alongside the old to show technical development. The end result is inspired pupils (Jewett Jr 2013).

It should be noted, however that the work of Jewett Jr (2013) is based on the author’s experience of teaching in his own class. It does not involve any sort of empirical investigation into hooks. Such an investigation only came about when McCauley *et al.* (2015) published the results of a study investigating the design of science video hooks. Not only is this the only empirical investigation into hooks of any kind, it is also the most recent publication concerning hooks. The authors describe the process of developing video hook resources and the establishment of a community of practice pertaining to science resource design. The paper articulates the engagements and reflections by participants with the collaborative design process. The overarching design progression for the three groups involved (Biology, Chemistry and Physics) is described through the lens of Practitioner Action Research (PAR). The project resulted in 35 e-book resources aimed at 12-15 year olds.

The work conducted in the former paper is the first of its kind and forms the grounding for the present research. As can be observed in the literature, the development of formal research into hooks is only beginning to emerge. This research specifically expands on the work of McCauley *et al.* (2015) by explicitly looking at the design process involved with the formerly mentioned physics group. Furthermore, at present, there is also no evidence with clear methodological foundations to verify the benefits of hooks other than limited teaching and teacher evidence

Chapter 2: Literature Review

(Hunter 1994, Jewett Jr 2013, Lemov 2010, Marinchech 2013, McCauley *et al.* 2015, McCrory 2011, Riendeau 2013). A distinct gap as such, is a formal investigation examining both the teacher and student perspective in relation to hooks, something that will be at the forefront of the current research. Thus, this thesis represents the first instance in which the modern definition of a hook will be formally implemented and tested in an authentic classroom context. The definition at this point is that hooks are a short instructional strategy, employed at the beginning of a lesson to augment students' attention, interest and engagement. Such an investigation is vital as Yang *et al.* (2013) posits that the majority of studies that examine multimedia, do so in experimental environments (Guzey and Roehrig 2012). Secondly, this research represents the first time that hooks designed in a video medium will be examined. The study of video is also an important novel factor to the research as Wang (2014) reports on the weak theoretical foundations, as presented in the literature, in relation to the implementation of video within instruction. Taking all of this into consideration, the results of the research will provide a novel contribution to knowledge pertaining to physics hook design, video design, hook implementation and pedagogy in the classroom along with the overarching impact of hooks on Irish teachers and students in science and physics education.

Table 2.1: List of all ‘Hook-Like’ instructional phases found in the literature

Author	Hook Like Phase	Description
Herbart (1901)	Preparation Phase	Part of an overall instruction model with three other phases.
Dewey (1933)	Sensing Perplexing Situations	Part of an overall instruction model with four other phases.
Heiss <i>et al.</i> (1950)	Explaining the Unit	Part of an overall instruction model with three other phases.
Atkin and Karplus (1962)	Exploration	Part of an overall instruction model with two other phases.
Schuck (1969, 1970, 1981)	Set Induction	First instance in which the start of the lesson was the focus of inquiry, however, the process does not fit in with the modern definition of a hook. Sets up the learning goals of the class.
Perrot (1982)	Set Induction	Described the work of Schuck with simple examples.
BSCS (1980)	Engagement	Engagement is the first part of the 5E model which includes Exploration, Explanation, Elaboration and Evaluation.
Keller (1984)	Attention	The first step in the ARCS motivational model.
Hunter (1994)	Anticipatory Sets	First instance in which the modern definition of a hook is described. It links back to set induction as the author notes that the set should let students to focus on learning goals.
Templeton (2008)	Hooks	Describes the process of hooking as ‘science in disguise’, giving students a new way to see the world.
Lemov (2010)	Hooks	Notes how hooks should be short introductory moments of a class that show off the best aspects of a subject.
McCrary (2011)	Hooks	Discusses the use of emotional engagement as a hook strategy during any point of instruction.
Zehr (2011)	Hooks	Utilises pop culture icons such as Batman to hook students. The focus of the article is in linking physiology and culture as opposed to hook methods.
Zavalani and Spahiu (2012)	Hooks	Employed Virtual Reality (VR) as a hook in engineering lessons. The focus of the article is on the learning processes associated with VR as opposed to hooking.
Marinchech (2013)	Hooks	Describes a hook as a short introductory moment that puts the material out in front. The hook is the introduction and does not permeate the rest of the lesson.
Jewett Jr (2013)	Hooks	Describes the use of hooks in physics lessons from a teacher perspective with numerous example given.
Riendeau (2013)	Hooks	Talks to the importance of hooking in class.
McCauley <i>et al.</i> (2015)	Hooks	Designed science video hooks through the development of a community of practice. First empirical investigation of hooks.

2.5 Chapter Summary

The review of the extant literature into hook-like pedagogies and hooks identifies that only recently, in relation to their prescribed definition (drawing on the combined constructs of attention, engagement, interest) that they have become the subject of research efforts. Historically, hook methods have formed the beginning phase of instructional models. More modern accounts focus on hooks as an individual unit of instruction encompassing the three constructs of attention, interest and engagement. In general, the terms are utilised in a colloquial and interchangeable fashion throughout the literature with no actual assessment of the impact of hooks on students. Moreover, while examples of hooks are given, little is offered in the literature in terms of hooks design and enactment, thereby, lending provenance to the primary research question; How can physics video hooks be designed and implemented to generate student attention, interest and engagement in physics? Hence, the current investigation is timely and warranted. Hook based instructional strategies have the potential not only to bring about educational change through affective and cognitive outcomes, but may also become part of a teachers 'toolkit'.

Having explored the various justifications behind this study, the next step is the design of a hook that can be employed in the science classroom, so that it will augment students' attention, interest and engagement, while also being simple and easy to enact in authentic learning contexts. At this stage, an exact hook design is fundamental to this research and will provide the basis for further inquiry. Thus, in the following chapter, 'Physics Video Hook Design Framework' the development of the hooks will be illuminated.

Chapter 3: Physics Video Hook Design Framework

3.1 Chapter Introduction

This chapter will delineate the specific design strategy used in the creation of the physics video hooks. The purpose of the design and decision processes reported here was to produce an instructional resource that would act as an effective hook when applied to science classrooms with second level students. As noted previously, hooks are a type of pedagogy that catch attention and serve as an enticement for learning. They are different from other teaching resources in that they are specifically designed to augment interest, engagement and attention among learners. The videos are designed to be an all-encompassing hook that can be easily utilised and provide a grounding for the following instruction based on students affective and cognitive reactions. (Marinchech 2013). The hooks were developed through a collaborative design project with pre-service science teachers and educators at the National University of Ireland, Galway (NUI Galway). As part of this venture, pre-service science teachers were recruited to work with a science and technology educator in the school. Three groups were formed and charged with the task of developing physics, biology and chemistry hooks, based on topics in the Irish junior science curriculum. This was an explicit strategy as the goal was to create interest in school science and syllabus based content. Therefore, the hooks in this study represent an internal hook that resides between the interplay of school knowledge and students' specific interests (McCrorry 2011). Over the course of the eight-week project, the physics group instigated a modified ADDIE (Analysis, Design, Development, Implementation and Evaluation) (Gustafson and Branch 2002) design framework as it allowed videos to be developed in a practical and efficient manner. In terms of the overarching design, the videos are informed by multimedia principles and cognitive load theory. Furthermore, specific design elements were embedded into the videos, which included relevance, questioning, discrepancy and novelty.

The physics video hooks represent the proto-design artefact being examined in this thesis. Thus, the process of design in its entirety will be explored presently to promote replicability and transparency for all stages of research. This chapter will follow the steps set out by the ADDIE model so readers can glean an in depth understanding of the choices made throughout development. This initial discussion will focus on the modified instructional design framework instigated.

3.2 Instructional Design Framework

Instructional design refers to the detailed design and evaluation of educational materials to facilitate learning and performance (Martin *et al.* 2013). It is a systematic and iterative approach to developing pedagogical resources and programs (Smith and Ragan 1999). As noted by Watzman and Re (2012), the essence of design resides in economic performance. Given this, the ADDIE framework was employed, however, other frameworks examined, including the ‘Pebble in the Pond’ design (Merrill 2002) and the ‘Spiral Model’ as described by Goodyear (2013) were considered, but their emphasis is on classroom teaching strategies as opposed to instructional resources. Hence, the creation of the physics video hooks is informed by a modified version of the ADDIE instructional design framework to allow for a methodical and efficient development process.

ADDIE stands for Analysis, Design, Development, Implementation and Evaluation (Gustafson and Branch 2002). The instructional model provides flexible guidelines for the construction of teaching and learning tools (Moradmand *et al.* 2014). It is a common approach used in the development of instructional programs and training courses as it can be easily applied to the creation of any type of instructional materials (Martin *et al.* 2013). The process is considered to be iterative and sequential (Molenda 2003), yet, the development of the physics video hooks, like many design projects, was not linear. For convenience, steps may be presented in an undeviating manner, however, designers transition in and out of the various phases as needed. This allows for a ‘self-corrective’ strategy in which mistakes can be identified and amended at almost any stage of the design (Gustafson and Branch 2002). The hooks project worked through every phase of the ADDIE process barring the Implementation (I) step. Practically, it was not within the scope of the design project to conduct a classroom-based implementation stage in a rigorous and informed manner. Given this, the current doctoral thesis represents the implementation phase. Previously, this was not possible as the hooks were designed and created within the remit of an eight-week project based in the summer months. Therefore, the exact instructional design model used was a four-stage model instead of five, changing ADDIE to ADDE*. To compensate, the project employed an enhanced evaluation stage which will be described in the latter sections of this chapter. The four steps involved in the modified instructional framework will now be discussed sequentially.

3.2.1 Analysis

Problem analysis characterises the questions and issues that a design is intended to address (Edelson 2002). A description of the goals one wants a design to achieve is warranted along with restrictions and limitations of the study. Analysis is informed gradually through incorporating data from a number of sources. A design process often begins with an idea that through empirical and meta-analysis evolves and adapts until implementation (Edelson 2002). The analysis phase of the current design process is informed by literature on hooks, but also required evidence pertaining to the target classrooms, stakeholders within those classrooms, modern trends in science education and an examination of pedagogical methods that can augment the constructs of attention, interest and engagement, thus rendering themselves suitable as hooks. With this type of analysis, a plan of design is gradually knitted together that reflects the issues to be addressed by the research (Edelson 2002). The key issue hooks target, is the decreasing student numbers in physics and science coupled with decreased interest and engagement among students. Throughout analysis, a detailed investigation of the following areas took place;

- A. The Irish secondary educational system and in particular, identification of the student year groups that the hooks should target.
- B. The characteristics of stakeholders within these classrooms. Both teacher and student needs require incorporation into any hook design.
- C. Based on the evidence generated in the previous two areas, identification of the type of pedagogical resource or methodology that would best act as a hook?

The evidence compiled throughout this analysis will now be conveyed.

3.2.1.1 The Irish Education System

In Ireland, approximately 99% of students attend non fee paying public schools (DES 2011). There are a total of 721 secondary schools with 25,374 full time staff with an ever increasing number of students at 362,847 in the academic year 2012/2013 as opposed to 359,047 in 2011/2012 (CSO 2017). The public system comprises of eight years of primary schooling including two infant years. This is followed by five to six years of second level schooling, three years at junior cycle and two or three in senior cycle (DES 2011). The junior cycle exam takes place after three years of secondary schooling. It caters for students between eleven and fifteen and ends with terminal

exams. A transition year then is offered directly after the junior cycle and this is the only optional programme. The senior cycle caters for students between 15 and 18. Within the senior cycle, there are three programmes. The Leaving Certificate is the most widely taken. In this course, students take a minimum of six subjects. The examination for each course is worth a total of 100 points, with descending points for lower grades. Points are used for access into third level institutions. The other less common senior cycle options include the Leaving Certificate Vocational Programme (LCVP) and the Leaving Certificate Applied (LCA) (DES 2011).

Based on the landscape of Irish education, it is positioned by the researcher that specifically targeting students in the first two years of junior cycle at the ages of eleven to fifteen to be the optimum time to enact a hook implementation. According to Tytler (2007), a decline in interest in school science in the first years of secondary teaching are common. Research should focus on these years as this is when the most affective and intellectual progress is made (Tytler 2007). Archer (2010) adds to this argument and states that that by age 14, students' perceptions of science are already formed. Moreover, numerous authors note that the first years of secondary schooling are a key interface for interest development (Christidou 2011, Walper *et al.* 2014, Zachary *et al.* 2000). Given this, the hooks are designed to target the first and second years of junior cycle. Lending further credence to this strategy is that students after junior cycle specialise from science to physics, chemistry and biology. Therefore, the development of interest and engagement in physics when students are in junior cycle has the potential to positively benefit student numbers in this subject area throughout senior cycle and beyond.

3.2.1.2 Classroom Stakeholders

An analysis of the target classrooms led the project to take into account the stakeholders and users of any hook based intervention. In light of this, teachers have to be a distinct focus of the design. The argument is put forward that teachers are the gatekeepers of students (Gomes 2015) and that to reach the student audience with any new resource (in this case a hook artefact), teacher approval is essential. Teachers are the core determinants of interest (Rotgans and Schmidt 2011c) and engagement (Darby 2005) in their classrooms. Therefore, any hook created should meet their requirements. Drawing from discussions in the literature review, teachers are under curricula and time pressures, so any hook that they may consider must be easy to use and chronologically short. Furthermore, teachers should not have to spend an inordinate amount of time learning how to apply

the hook. The initial design should cater for a seamless and swift integration into the science classroom. Without such design considerations, the hook may never be employed effectively or even reach students (Szeto and Cheng 2014).

Today's students, the target audience of hooks, are often referred to as 'digital residents' with a constant online presence (Connaway *et al.* 2011, White and Le Cornu 2011). Internet functions of social media and streaming are currently used ubiquitously by the current generation of students (Szeto and Cheng 2014). As stated by Seymour (2001, p. 11) "In a world beyond the school gates, students are surrounded by the modern technology that enables them to access images, sounds and text that interest them, at their own pace." Students command a wide range of digital resources in their lives and according to Prensky (2012) suffer from lower attention spans as they are habituated with a wide range of activities. Duffy (2007, p. 119) asks "how can we as educators engage the YouTube, Google-eyed generation?" Indeed, the analysis phase must ask the same question. Given the makeup of today's students, any hook must grab students' attention in a fast-paced manner.

Based on the user needs in the classroom, it was decided that the hook design should revolve around a piece of educational technology. The exact technology had to appeal to modern students while also being easy to employ in class by teachers. Navigating the choice of educational technology considered numerous variables that will be discussed in the following section.

3.2.1.3 Educational Technology

The models and roles of multimedia in science education have gained theoretical and practical weight due to the readily available amount of technology present in society that is permeating into classrooms (Gilbert 2005, Mariooryad *et al.* 2014). Given this, the argument is put forward that an educational technology based hook is a salient way of developing the constructs of attention, interest and engagement among students (Arnone *et al.* 2011, Linnenbrink-Garcia *et al.* 2010, Middleton and Mather 2008). When discussing students, Fernández-Lopez *et al.* (2012, p. 77) state that "the use of electronic devices and multimedia content increases their interest and attention". Guzey and Roehrig (2012) note that the use of learning technologies in science classrooms has been shown to increase students' attention, engagement, and interest in science. Such sentiments are echoed by Tan and Pierce (2012) who suggest the use of multimedia as an icebreaker for initiating classes. Is it postulated by the author that educational technology, with positive affective

impacts on the student body, is beginning to weave its way into classrooms, rendering it wholly suitable for hook applications (Tan and Pierce 2012).

Although appropriate for the purposes of hooking, the implementation of a piece of educational technology into the secondary school context is not a simple task. According to Chandra and Watters (2011), more research is warranted into developing and understanding the impact that educational technology has on classroom dynamics (Chandra and Watters 2012, Gerard *et al.* 2011, Guzey and Roehrig 2012). A current global trend is the employment of educational technology tools in schools and assessing their impact on pedagogy (Szeto and Cheng 2014). One of the challenges with educational technology, however, and one of the core features of this research is the complete integration of technology into naturalistic contexts (McGarr 2009). According to Pegrum *et al.* (2013), appropriate technology based resources, steeped in pedagogical theory have only begun to appear and more of these resources are sorely needed. This is reiterated by Liu *et al.* (2009) who talks about the need for research in areas to support active and adequate use of educational technology in the classroom. Simply placing various technologies into classrooms does not guarantee successful learning (Liu *et al.* 2009).

Indeed, numerous authors outline the barriers to the incorporation of educational technology into teaching including; lack of equipment (Guzey and Roehrig, 2012; McGarr 2009), time and support (Kopcha 2012, McGarr 2009) along with teaching methods and management issues (Awan 2012, Bingimlas 2009). Consistent with such barriers, the design of hooks requires an educational technology platform that can be effectively integrated into the classroom. In light of this, key features of any hooking technology must account for ease of use, familiarity and simplicity while also being recognisable to the student body. With this remit, the hooks were constructed in a digital video format. Based on the aforementioned stakeholder needs, it is posited that video is readily recognisable to both students and teachers, while also being ‘easily’ integrated into the classroom context. The rationale behind this decision will be demarcated presently.

3.2.1.4 Digital Video

Berk (2009) describes a teaching scenario in which a teacher darkens a classroom. As students attempt to anticipate what is happening, the teacher plays a video clip. The author (Berk 2009, p. 11) describes this as a “fireball stimulus package” for new topics with a huge impact that

completely grabs student attention and interest (Berk 2009). This research aims to simulate this scenario through the creation of physics video hooks.

Video is at the vanguard of educational technology (Sykes 2012). Many authors espouse the benefits of incorporating video into instruction (Jones and Cuthrell 2011, Szeto and Cheng 2014, Tan and Pearce 2012, Zhang *et al.* 2006). According to Jones and Cuthrell (2011), students make positive gains in learning outcomes from the inclusion of video technology in the classroom. Video taps into core intelligences that encompass all the ways in which humans learn (Fill and Ottewill 2006, Jones and Cuthrell 2011, Steffes and Duverger 2012).

Video can activate verbal, audio, linguistic, emotional and musical intelligences in a single moment (Jones and Cuthrell 2011). Pertaining to hooking, it is argued that video can be used as a ‘mood primer’ in class (Steffes and Duverger 2012). Video is a dominant form of media, as Card (2012) states that pictures, especially moving pictures take priority in the learner’s mind. Moreover, Winkler (2005, p. 5) reports, “80 – 90% of all neurons in the human brain are estimated to be involved in visual perception.” Humans are adapted to interact with moving visual images, the same we encounter on a daily basis making video vivid and compelling (Miller and Zhou 2007). In addition, Vaughan (2004, p. 176) states that “digital video is the most engaging of multimedia venues”. Based on this evidence, video is put forward as the ‘best fit’ option that has the potential to be an effective vehicle of hook based pedagogy.

As noted previously, one of the main considerations throughout the analysis phase is the identification of the target users of the hooks. In this instance, science teachers and students (Peterson 2003). From a teacher perspective, digital video is easy to use and disseminate both locally and beyond. Andrews (2012) posits that video can be ‘pulled’ by learners and ‘pushed’ by teachers. This means that students can have access to the videos and teachers can present the content in a suitable instructional manner. Due to this, teachers have increased control over the pace of learning (Andrews 2012) lending to the role of video in fulfilling pedagogical requirements (Fill and Ottewill 2006).

From a student user perspective, the demographic of YouTube users aligns with the current demographic of students (Duffy 2007, Steffes and Duverger 2012). Therefore, students are more likely to identify with video content (Steffes and Duverger 2012). Furthermore, video can also display hard to capture phenomena that are common in physics such as the density of liquids or

the conservation of energy. It has the ability to present both static and moving material (Harwood and McMahon 1997) that inform rich and realistic contexts, referred to by Kumar (2010, p. 14) as “macro-contexts”, allowing students to observe the processes and nature of science (Vaughan 2004).

As noted, there are several benefits to using video as a hook delivery method; however, it has certain limitations and drawbacks. As a whole, educational technologies for instructional practices have struggled to be fully effective in science classrooms (Mayer 2002) and video is no different. The integration of video into a classroom hinges on the provision of appropriate pedagogy (Bell and Bull 2010) embedded within a larger learning context (Schwartz and Hartman 2007, Zhang *et al.* 2006). Furthermore, Gilbert (2007, p. 141) states that “much more research is needed on the impact of visualisations”. Little research has been conducted into how video impacts on students’ psychological processes, both in relation to affect and cognition in class. Given this, the current thesis is embarking on a new and novel research agenda particularly in relation to video design and student impact. Indeed, with the analysis phase complete, design is the next step in the ADDE* model. The design structure built into the videos coupled together multimedia and cognitive load theories. The following writing will delineate the processes involved.

3.2.2 Design

The information developed during the analysis phase provided the relevant data to assist in creating an overarching design strategy for the physics video hooks. Per the literature, the design phase includes the identification of objectives to be completed and elements to be built into the videos (Peterson 2003). The objectives defined placed an emphasis on embedding a theoretical framework into the videos based upon the principles of a) cognitive load theory and b) multimedia design. It was decided that these principles needed to be integral to the design as the creation of videos presents pedagogical hurdles that need to be overcome (Gilbert 2005). The design and structure of any video must be appropriate for instructional use. Videos should be short and to the point. It is suggested that they should be a maximum of three minutes unless specific learning outcomes require longer videos (Berk 2009). The narrative (if any) should include everyday language that is direct to the purpose of the video. The same applies to audio/visuals. Any extraneous shots should be removed (Berk 2009) since video imparts a high cognitive load due to the transience of information (Mazur 2016, Spanjers *et al.* 2011). Moving images are a natural way of presenting

information, but are often far too fast and complex to be adequately perceived by the cognitive processes in the brain (Kozma 1986, Spanjers *et al.* 2011). Within video, there are sometimes too many moving parts occurring simultaneously. The mind and the eye are working together to figure out the images and sounds, but often cannot keep up. Some students don't even know what to focus upon (Gilbert 2005). In essence, the design phase employs an avoidance strategy with both cognitive load theory and multimedia design ideologies being core attributes of the physics video hooks. Both approaches with examples from the videos will be described in the following sections.

3.2.2.1 Cognitive load theory

Cognitive load theories are concerned with the difficulty of material that is learned. They encapsulate the process of arranging information in such a fashion that it aligns with cognitive architecture in the brain (Sorden 2012). Hence, allowing new information to be assimilated with a higher degree of ease (Ljubojevic *et al.* 2014, Paas *et al.* 2003). As explained by Mayer and Moreno (2003), cognitive overload is an issue when processing demands exceed the learner's cognitive capacity. It is suggested that to lower cognitive loads, information needs to be structured in a manner that reduces difficulty (Sweller 1994). The capacity of working memory is limited. Therefore, if an activity contains too much information, learning will be hampered (De Jong 2010). It is suggested the design of instruction should be optimised to avoid cognitive overload (De Jong 2010, Smith and Ragan 1999). Within this research, one of the core design goals was for the physics video hooks to be aligned with this philosophy. This is described by Mayer and Moreno (2003, p. 45) as a "central challenge for instructors (including instructional designers) ...". The following strategies were set out in the design phase to reduce the cognitive load throughout video hooks.

One of the most efficient ways an instructional designer can reduce cognitive load is through streamlining the video content. Any extraneous content should be removed as students' attention may focus on the incorrect aspects of the video. Student attention should be directed toward essential information (Mayer and Moreno 2003, Berk 2009). The two main streamlining methods include signalling and weeding. Signalling limits words and narratives, however, it highlights certain sections of interest or application (Spanjers *et al.* 2011). Visual or aural cues can be utilised to orientate the student through a video and facilitate the extraction of necessary information. This reduces extra cognitive load as the learner does not have to work to locate the

most vital aspects intended for comprehension (Mayer and Moreno 2003). Within the video hook design, this was done by placing words on screen at pivotal times. The example in Figure 3.1 asks the viewer to explain the phenomena being observed by placing the word ‘Explain?’ on the screen. The second process is weeding where unnecessary information is eliminated from a multimedia project (Ibrahim *et al.* 2012). This principle applies to sounds, words and visuals. Irrelevant information diverts attention away from the intended focus (Mayer and Moreno 2003). In alignment with recommendations by Berk (2009) and Mayer and Moreno (2003), the hooks had any non-essential material removed by the teacher designers allowing for a clear and logical sequence of events. This is vital as redundant information can interfere with learning through the augmentation of working memory load (Kalyuga *et al.* 1999). In light of this, the hooks have a minimalist approach.



Figure 3.1: The signalling principle is employed in the ‘Sink or Float’ physics video hook by using the word ‘Explain?’ to orientate student thinking towards the learning content

3.2.2.2 Multimedia design

The promise of multimedia is that some students can learn more effectively from well-designed multimedia applications combining both visual and word based platforms rather than traditional

forms of instruction (Mayer and Moreno 2003). The multimedia principle, derived from dual coding theories (Paivio 1969, Paivio 1990), states that deeper learning occurs when words and images are used over words alone (Mayer 2002, Mayer 2005). Words are a single medium presentation format and the dominant vehicle for instruction (Mayer and Moreno 2003). However, as discussed previously humans are adapted to interact with moving visual images, the same we encounter on a daily basis. Humans naturally gravitate toward visual stimulation and this is potentially why Vaughan (2004) posits that multimedia can electrify the action centres of peoples' brains. Pertaining to multimedia design, there are two principles that were inserted into the physics video hooks' design.

The first is the multiple representation principle that states it is better to present information in word *and* picture format rather than in a singular fashion. Put simply, two modes of representation are better than one (Mayer and Moreno 1998). An example of which is highlighted in Figure 3.2. This principle suggests that multiple formats provide multiple platforms to retrieve and process information (Kalyuga *et al.* 1999).

The second is the split attention principle of multimedia, which posits that words should be delivered in an auditory manner rather than visually where possible. Narration and visual information are processed in different systems of the brain (Mayer and Moreno 1998). It is argued that narration is beneficial as the human eyes should not be subject to concurrent information (Mayer and Moreno 2003), that is, within the physics video hook design format, too much on screen text. Therefore, a narrative was utilised when one or two words on screen would not explain the phenomena being demonstrated as per the previously described multiple representation principle. As recommended by Berk (2009) and Mayer (2008) the narrative was written in everyday and non-scientific language. With this, narration formed an integral part of the video hook design.



Figure 3.2: Screenshot from the ‘Energy Conversions’ physics hook video displaying the use of the multimedia principle as the word ‘Blowtorch’ is displayed with a corresponding image

Finally, during the design phase, specific topics within the physics syllabus on which to base the videos were selected. However, this was a back and forth process between the design and development phases. A process of experimentation had to be instigated to refine a list of topics that could be adequately represented in a visual medium. In addition, the design phase was used to figure out specific design elements that could be positioned in the videos to augment attention, interest and engagement among learners. The specific list of instructional design elements built into the hooks include; a) Relevance, b) Questioning, c) Discrepancy and d) Novelty. The process of constructing the hooks, informed by the previous phases will be elaborated upon in the development phase.

3.2.3 Development

Still pertinent today, Mitchell (1993) intimated that too often educators attempt to make instruction more interesting by appealing to student interests outside of the realm of the classroom. Students may be more engaged in general, but not necessarily with the content of the class. This was something the development phase aimed to avoid. In constructing the hooks, the designers directed

Chapter 3: Physics Video Hook Design Framework

their efforts to create a resource that was grounded in scientific content. The overarching goal is to hook students by developing interesting and engaging subject matter embedded in the physical sciences. This process will now be explored.

The development phase builds upon the efforts of the former phases and comprises the construction of a product (Peterson 2003). Initially this involved testing and experimentation. The physics video hooks display numerous scientific phenomena, all of which needed to be verified in the laboratory to establish their visual suitability before filming. Upon completion, a list of eleven physics based topics with corresponding storyboards were developed. These included; magnetism, convection, atmospheric pressure, density, centre of gravity, pressure, conservation of energy, friction, energy conversions, floatation, and sound (see Table 3.1). The argument can be put forward that the variance within the video hooks in terms of subject matter content, may reduce the power of prediction within research. However, it is positioned by the researcher that any resource created for the classroom must maintain its core design sensitivities and allow for changes in topic. In addition, numerous videos needed to be created so that an overarching assessment of the design sensitivities can be established with numerous interventions across multiple classrooms. The creation of one video would prove restrictive from both a pragmatic research and teaching standpoint.

Table 3.1: List of hook videos with description and duration

Hook Video	Description	Duration
Atmospheric Pressure	This hook displays how atmospheric pressure can be used to crush aluminium cans. A can is filled with steam and then inverted into cold water. The steam condenses to create a vacuum and the pressure of the atmosphere forces the can to implode.	1:36
Centre of Gravity	This hook takes objects that do not intuitively balance and puts them together. Three separate balancing acts are presented; the combination of a spoon, fork and toothpick, a hammer ruler and string and finally a sledgehammer, twine and a metre stick.	1:45
Conservation of Energy	This hook displays the concept of the conservation of energy, the principle that energy cannot be created or destroyed; it can only be changed from one form to another. In the experiment, a weight is tied onto a piece of string and used as a pendulum.	1:08
Convection	This hook highlights an example of convection using tea bags. As the tea bag burns, hot air is being created, as well as a thermal or convection current under the bag. Cold air is drawn in below and the tea bag rises into the air.	2:03
Density	This hook displays a density tower. Various immiscible (will not mix) liquids are placed in a graduated cylinder to see which ones are the most and least dense.	2:57
Energy Conversions	This hook turns chemical energy into heat energy and then into kinetic energy by using water as an energy transporter and converter in a simple steam engine.	1:34
Flotation	This hook explores the density of objects in relation to water. Objects include fruit, soda cans and eggs.	1:28
Friction	This hook examines friction as a force and lubrication. It demonstrates the frictional force by inserting a knife into a graduated cylinder of rice.	1:11
Magnetism	This hook uses neodymium magnets to propel a ball bearing across a table. The speed of the ball is then measured on screen.	1:37
Pressure	This hook explores pressure and area by placing a balloon on a single nail versus a bed of nails.	0:42
Sound	In this hook, the sound made by a tuning fork is explored. If the tuning fork is struck, the vibrations created in the air produce a quiet sound and force. The force is then used to create a piece of art.	1:29

Once a list of physics topics that could be visually represented through film were established, the next step involved deciding how the subject matter should be depicted in the videos. Throughout this process, the literature was examined for specific design elements that could work in tandem with the physics content to make the hooks more interesting and engaging. As mentioned in chapter 2, there are very few examples of hooking strategies in the literature.

Therefore, in order to broaden the scope of the development phase, an examination of instructional techniques used to stimulate attention, interest and engagement was conducted. This ‘cobbled’ together (Edelson 2002) a theoretical bricolage of specific elements used in instruction to generate the aforementioned constructs with the overall aim of embedding such techniques into the hook videos. Numerous strategies are noted in the literature to increase attention, interest and engagement including; well organised and vivid texts (Schraw *et al.* 2001), discrepancy and conceptual change (Cakir 2008, Childs 2016, Jewett Jr 2013, Thornton and Sokoloff 1998) hands on practical activities (Regan and Childs 2003, Zahorik 1996), relevance (Osborne *et al.* 2003, Roe 2011, Rotgans and Schmidt 2011b) puzzles (Chen and Darst 2002, Rotgans and Schmidt 2011c) teaching in a constructivist manner (Drudy 2011, Richardson 2003), active learning (Exeter *et al.* 2010, Prince 2004, Watkins and Mazur 2013), questioning (Bergin 1999, Jewett Jr 2013) and the use of educational technologies (Fernández-López *et al.* 2012, Clifton and Mann 2011, McCauley *et al.* 2015). This list was distilled down to the design elements that would translate effectively into the visual medium of digital video. As a result, the specific design elements embedded into the videos are a) Relevance, b) Questioning, c) Discrepancy and d) Novelty. These strategies were built into the videos in a structured manner. They will be fully elaborated upon presently with examples from within the videos.

3.2.3.1 Relevance

Osborne *et al.* (2003) states that without relevance, sustaining interest is difficult, if not impossible. Perceived usefulness in content, creates an inherent interest (Hulleman and Harackiewicz 2009, Palmer 2004, Rotgans and Schmidt 2011c) leading to attention (Jensen 2008) and engagement (WellcomeTrust 2011). Therefore, relevance in teaching can provide a way of hooking students. Indeed, Bennett *et al.* (2007) notes that the aspirations of developing context based education lies in fashioning affective responses from the student body.

According to Kember *et al.* (2008, p. 260), relevance can be established by showing how theory can be applied in practice, establishing relevance to local cases, relating material to everyday applications, or finding applications in current newsworthy issues. Further, relevance can be integrated into teaching by “relating the activity or instruction to the student’s interest, future activities, or past experiences in an attempt to show its value or worth” (Newby 1991, p. 196). Such improvements in instruction are directly linked to motivation and provide a possible

cessation to ‘I can’t’ and ‘I don’t know’ attitudes that plague classrooms (Pikaar 2013). An investigation by the Wellcome Trust (2011) demonstrated that levels of student engagement were correlated to a teacher’s use of transferability of learning to ‘real world’ scenarios including future study. Furthermore, research by Roe (2011), postulated subjects that were relevant to real life were the key to students’ education (Roe 2011). Chamany *et al.* (2008) advocate the benefits of social contexts as a basis for relevance in teaching. The social relevance of a lesson that is clear to an educator, once realised by students, can add layers to their learning. Incremental avenues can be generated for immediate development and future memory retrieval (Chamany *et al.* 2008). This strategy is employed by Mitsoni (2006) who discusses ‘connectedness’ with regard to history and the real world. In relation to archaeology, “student’s interest comes alive when they ask questions about things that really puzzle them – like what the toilets were like, how people were buried, how long they lived or how the women were treated.” (Mitsoni 2006, p. 166). What the toilets were like will most likely not come up on any exam, however, it makes the content relatable and meaningful to the student (Mitsoni 2006).

Relevance can also be embedded within instruction through the development of cross curricular links between subject areas. As Zachary *et al.* (2000) states, making connections between science and other disciplines is a key component of teacher professional standards. More recently, in a study by Oon and Subramaniam (2011), the authors posit that cross-curricular activities can enhance students interest in physics since links to other subject areas promote a wider interest in the topic being taught.

Pertaining to the physics video hooks, the relevance strategy employed took a threefold approach. Firstly, relevance was constructed throughout the videos by using items students would find and see in everyday life. This ranged from foodstuffs such as maple syrup and honey, to hardware such as hammers, weights and aluminium cans (Figure 3.3). This approach enables the viewer to observe how interesting and engaging scientific phenomena can be constructed with common objects.

The second relevance strategy grounds the physics videos in the content of the Junior Certificate Irish science syllabus. All video content can be linked back to sections of the syllabus or textbooks. This makes the videos more useful than other videos that may contain extraneous

content. The hooks are wholly relevant to the science curriculum giving the video value from a teacher and learner perspective.

The final relevance strategy was the use of cross curricular links within the videos. Links to art, music and in particular mathematics were made to broaden the scope and appeal of the videos and to show the various connections between science and other subjects. In addition, this was done in order to bring all videos to a similar cognitive standard.



Figure 3.3: One of the relevance strategies embedded into the videos. This figure displays household materials used in the ‘Density Tower’ physics video hook. As the objects appear on screen, the correlating word also appears on screen.

3.2.3.2 Questioning

According to Bergin (1999), the basic act of questioning facilitates student attention. Questions allow students to make their own inferences and connect concepts (Jewett Jr 2013). Numerous authors state that questioning is one of the most vital roles of the teacher (Gall 1970, Petty 2009, Redfield and Rousseau 1981). According to Aschner (1961), questioning is one of the best ways by which teachers stimulate student thinking. The role of the teacher in questioning and communicating the meaning of the learning material is imperative (Daschmann *et al.* 2011). Darby

(2005) presents a coaxing questioning strategy that establishes relevance in class. The use of coaxing questions allows students to contribute their knowledge and build up a picture of a topic. In this way, the teacher does not dictate, rather directs contributions, placing more emphasis on certain information depending on their intended direction of learning. As students interact, a representation of the subject is formed in their minds that is directly pertinent to them. Students identified this method as helping them learn (Darby 2005, Richardson 2003).

Another strategy is to incorporate higher and lower order questions to promote student engagement (Redfield and Rousseau 1981). The majority of question classification systems are based upon cognitive thought processes that vary from higher to lower levels (Gall 1970). Petty (2009) demonstrates this process by using the human body as an example. Lower order questions are straightforward questions that require a student to recall basic knowledge. For example, “how many bones are there in the human body?” (Petty 2009, p. 200). Higher order questions, however, force a student to figure something out or establish their own opinions and views. For example, “what would happen if humans didn’t have a skeleton?” (Petty 2009, p. 200). Thus, the phrasing and positioning of questions can heavily impact upon their effectiveness in class.

Puzzles can also be regarded as a form of questioning. Puzzles are an effective tool as they form a type of cognitive stimulation that triggers interest (Rotgans and Schmidt 2011). They are deemed irregular and unusual questions that require divergent thinking. Mitchell (1993) states how puzzles really make students use their brains, something the author presents as a rarity in regular class time.

Facilitating attention through questioning (Bergin 1999) aligns perfectly with the primary aim of the physics video hooks. Given the aforementioned exploration into questioning, two types of questions, lower order and higher order were used in the videos. When and where this strategy was employed is heavily dependent on the content of the video and when opportunities for questions within footage present themselves. The following are examples of generic questions either presented on screen or asked by the narrator throughout videos.

- A. “Can you explain this?”
- B. “What is happening here?”

The questions are very simple and direct student thinking toward the central science behind the phenomena within the video. They are employed to keep attention focused and make the video easier to follow.

The second type of question is a higher order more complex question. For example, during the pressure video in which a balloon is pressed against a bed of nails and then against one nail, the narrator asks –

A. “Why was the balloon safe on this bed of nails, but popped on this one nail?”

The second strategy was employed at the end of the videos so that students are left pondering about the exact science behind what they observed. After these questions are asked, the video ends so it’s does not compromise the aims of the design phase to align the videos with the cognitive load theory and multimedia design.

3.2.3.3 Discrepancy

Discrepant and conceptual based pedagogical methodologies are noted by a number of authors as ways to stimulate interest and attention among learners (Thornton and Sokoloff 1998, Cakir 2008, Edelson and Joseph 2004, Bergin 1999). When employing this method, an educator presents an issue or topic that has associated misunderstandings. Students often hold misconceptions that are at odds with scientific explanations (Broughton *et al.* 2010). The intuitive knowledge of a child based on their experience has been coined ‘children’s science’ (Duit and Treagust 2003). Narrative cognition describes how young students explain scientific phenomena. That is, students respond to, and make sense of situations according to vivid memories or episodes of their earlier lives that shape their views (Thompson and Logue 2006, Tytler 2007). Klahr *et al.* (2011) report on young students’ knowledge of the solar system comprising of geocentric and heliocentric beliefs. Neale *et al.* (1990) gives the example of a young boy believing that shadows emanate from the human body. As the teacher presents new topics with the truth behind concepts, the revelation of a gap in the learners’ knowledge may spark a flame of curiosity inspiring interest (Bergin 1999, Edelson and Joseph 2004, Rotgans and Schmidt 2011). Jewett Jr (2013) reports on the utilisation of mysteries and magic as hooks in class. Mysteries such as ‘why is the sky blue?’ directly tackle student misconceptions and are a quick way to spark interest (Jewett Jr 2013). Riendeau (2013) is an advocate of cognitive conflict and believes that hooks should not be explained to students as

the goal of the hook is to get them wondering about the following instruction. The author states “you are not looking for answers... you are trying to get the students so interested that they seek answers for themselves” (Riendeau 2013, p. 380). Thus, students should be given time to generate their own explanations for prolonged engagement.

Based on the literature above, discrepancy was a core strategy in the video hooks build. Through the medium of digital video this involved the creation of visuals that look implausible or nonsensical, akin to magic tricks. An example of which is Figure 3.4. It displays a screenshot from the ‘Centre of Gravity’ physics video hook in which a sledgehammer and a metre stick are connected with twine and balanced on a table. As can be observed, this is not an intuitive visual. Narrative cognition attempts to explain why the items are balanced, thus providing the drive for discrepancy, interest and engagement.



Figure 3.4: Example of a discrepant event in the ‘Centre of Gravity’ physics video hook

3.2.3.4 Novelty

The argument is presented that novel stimuli and resources grab attention and interest (Burke and James 2008, Palmer 2009, Zahorik 1996). White (2010, p. 371) states, “communications in the age of information overload are more likely to be successful if they find new ways of getting and keeping attention”. Hence, novelty can mediate and direct attention (Burke and James 2008, Itti and Baldi 2005, Silvia 2008). Novel stimuli work in association with curiosity and challenge while substantially impacting the amount and depth of information processing in the brain (Burke and James 2008). Variety and novelty may result in greater attention, interest, recall and behavioural intentions (Kashdan and Silvia 2009, Silvia 2008) since new events act as a form of surprise (Itti and Baldi 2005). Curiosity driven behaviour through novelty is a well-defined human trait (Kashdan and Silvia 2009) with possible associations to dopamine receptor genes (Itti and Baldi 2005). As such, unpredictable moments traverse all stages of neural processing indicating that novelty has the potential to be central to learning and memory formation.

The scientific and psychological basis for novelty within instruction, as explained in the former paragraphs, forms the rationale behind efforts in the development phase to fashion the videos in a novel manner. This involved a conglomeration of all the aforementioned strategies in unique and unusual ways. The goal is to generate accumulative novelty so the hook content acts as a form of surprise (Itti and Baldi 2005). Indeed, the choice of video technology as the hook medium was made, along with other justifications, on the premise of creating a novel event in class.

3.2.3.5 Development: Build Summary

Demarcated in the former writing, the four design elements of relevance, questioning, discrepancy and novelty were thoroughly researched and built into the videos in a variety of fashions. At this point, the phenomena intended for filming, based upon the Irish syllabus, were selected. Taking the aforementioned design elements, the phenomena were enhanced where possible. Employing a storyboarding process, exact shots and transitions were set out within the videos. Storyboarding provides diagrammatic representations of the video along with narratives for efficient communication between design members (Jantke and Knauf 2005). The diagram attempts to convey in static pictures the flow of a finished video or film (Goldman *et al.* 2006). Utilising this as a baseline for the development phase, the videos were then filmed by a professional camera man and directed by the teacher participants over two days in a laboratory setting. The model of camera

used was a Canon 7D. The videos were edited on multiple occasions, again with the input from all designers, using Adobe Premier Pro CC.4.

3.2.4 Enhanced Evaluation

Progressing through the modified ADDE* model after the videos were filmed, an enhanced evaluation step was instigated to counterbalance the lack of an implementation phase. This process adopted a twofold approach. Firstly, weekly meetings were conducted throughout the eight weeks to critique and assess the work by the three pairs of teacher designers. This was a participatory and collaborative approach mediated by the project leader in which all ideas and choices were compared and contrasted. Where appropriate, modifications were made to improve the end product. The goal of this evaluative procedure was to provide formative feedback that would interlace between every step of the ADDE* model. This was a reflective process, similar to formative measures conducted by Moradmand *et al.* (2014) in which evaluation is present during every phase of instructional design.

The second evaluative step was conducted nearer the end of the project where substantial edits to the video hooks could still be made. Briggs *et al.* (1991) states that products should be tried out on members of the targeted population. Our target population and classroom stakeholders are both teachers and students. Therefore, it was decided to get members of the other design teams to provide a fresh critique of the videos from a science teacher perspective. In this way, all design members could put forward critical subjective expert opinions (Briggs *et al.* 1991) to enhance the evaluative procedure. Thus, this method allowed the videos to be revised in relation to identified teacher needs. Two separate pairs of teachers worked as designers on biology and chemistry hooks. These teachers (all junior science teachers) evaluated the physics video hooks based upon the following criteria:

- A. The characteristics of target science teachers
- B. The characteristics of target science students
- C. The characteristics of the science classroom

This provided two sets of stakeholder feedback based upon a needs assessment in what Briggs *et al.* (1991) describes as subjective expert opinions. The author states, “experts can usually provide insights for decision makers that are absent from more objective methodologies” which in this

research is a full-scale implementation phase (Briggs *et al.* 1991, p. 228). Edits and revisions were conducted based upon the user generated feedback in the two-pronged enhanced evaluative procedure.

3.3 Technical Enumeration of a Physics Video Hook

In addition to the previous overarching description of the hook design build, the following will enumerate the Centre of Gravity (CoG) hook specifically to give the reader and more detailed insight into the videos. With the CoG hook, the aim was to display objects balancing together in a way that seems intuitively false or incorrect. Firstly, a spoon, fork and toothpick are balanced on the edge of a glass. Secondly, a slight larger display whereby a hammer, ruler and a piece of string are balanced. Thirdly, the former experiment is replicated and scaled upward with a sledgehammer, meter stick and roll of twine. The specific ideas were generated through internet searches, testing in a laboratory and piecing together physical materials that would overlap in a visual manner. To support this, everyday objects were selected to keep the hook in line with the previously noted relevance strategy and to allow for teachers and students to replicate the content. Moreover, the hook aims to explicitly display discrepant events to foster a level of disbelief and curiosity among the viewer.

To augment the design, in line with cognitive load theories of multimedia, the hook takes a minimalist approach with no irrelevant information. The video consists of a deliberate and slow build up from a small-scale display to a larger one. The words are narrative with in the video was also heavily streamlined. When they were used, it was a deliberate strategy to direct the viewers' attention to important content. The hook poses three specific questions (Table 3.2). The questions are used as a narrative cue before each balancing experiment. The aim is to reduce cognitive load and facilitate students in the extraction of essential information. By extension, comprehension of the content is fundamental to the hook design. In light of this, all questions are written in everyday and non-scientific language and placed into the video via voiceover. This was to reduce any split-attention effects as visual and aural channels of cognition can aid each other so that the viewer is not subject to an inhibiting amount of pictorial information.

Table 3.2: Narration used throughout the CoG hook with specific time points

Time	Narration
0:11s	'How do you find the centre of gravity between a spoon a fork and a toothpick?'
0:40s	'Now, let's see if we can find the centre of gravity between a hammer, a ruler and a piece of twine'.
1:14s	'Do you think this experiment would still work with a metre stick and a sledgehammer?'

The specific design strategies build into the CoG video hook are (a) Relevance, (b) Questioning and (c) Discrepancy. Relevance is a recognition strategy that demonstrates how physical and scientific phenomena can be created at home. It can also be recreated by the teacher and students in class. To aid this process, the equipment was placed on screen for at least five seconds. This was to allow to recognise the materials and potentially make a more personal link between their own knowledge and the hook content. Finally, the experiments themselves act as a form of discrepancy. The exact discrepant moments are placed at 0:32 s, 1:10 s and 1:25 s (see Figure 3.4). The theory is that the discrepant moments reveal a gap in the learners' knowledge. The three balancing experiments within the hook attempt to be as anomalous as possible to encourage interest and exploration of the scientific content. The video can be found at <https://www.youtube.com/watch?v=G5KnCcRPOf0>

3.4 Implementation

Within the physics video hook design process, an implementation phase would have been desirable, however, it would have been wholly unpractical within the remit and time restrictions of an eight-week project. When discussing the process of instructional design, Jonassen (2008, p. 21) notes, "Decisions are driven less by accepting principles than they are by constraint satisfaction and beliefs, some of which are culturally accepted and others are context specific". In this design process, choices were made based upon content specific constraints to enable the efficient completion of the project. Lending credence to this decision, Jonassen (2008) brings up the problem of adhering too closely to instructional design models, when they can be a limiting factor to some projects. Design is a problem solving process and ADDE* was the most efficient route to follow in creating a solution to a context specific problem of the science classroom. Jonassen (2008, p. 26) continues and characterises successful design as one that "must address the constraints imposed by the context". Taking this into consideration, the decision was made to

modify the instructional design process to accommodate particular constraints. Furthermore, the formalised implementation process was undertaken in schools over the period of this doctoral research. As a phase within the ADDIE model, it is distinctly larger, yet the research data derived will provide incremental avenues for further investigation.

3.5 Chapter Summary

This chapter explored the specific design strategy traversed in the creation of the physics video hook design artefact. Inspired by the literature on hooks and the intended affective outcomes of hook based pedagogies, the design framework was guided under a modified ADDIE instructional umbrella. Table 3.3 contains an overview of the various steps involved in each stage.

Table 3.3: Phases and sub-steps used in the construction of the physics video hooks

Analysis
- Analysis of teacher needs and requirements
- Analysis of student needs and requirements
- Identification of instructional techniques used to augment attention, interest and engagement
- Selection of digital video as hook medium

Design
- Establishment of specific goals and objectives to be completed
- Alignment of design with the principles of Cognitive Load Theory
- Alignment of design with Multimedia principles
- Selection of curriculum relevant topics to base video content
- Delineation of design elements to be tested during development phase

Development
- Refinement and testing of hook video content and specific design elements
- Collaboration with camera man through story boarding process
- Direction and recording physics video hooks

Enhanced Evaluation
- Formative weekly evaluation based upon group meetings with corrections/modifications
- Subjective expert evaluation by teachers/designers
- Edits and revisions conducted

The finalised suite of physics video hooks can be found online at both;

<http://www.sciencehooks.scoilnet.ie/physics/centre-of-gravity/>

<http://tinyurl.com/physicshooks>

Pertaining to an intervention, the thesis has elucidated the design of its core artefact, the physics video hook. In accordance, an exploration of the theoretical foundations of hooks and the intended outcome of utilising hooks is warranted to provide a frame of reference for classroom based research activities. Furthermore, this chapter has elucidated the gap between technology and

Chapter 3: Physics Video Hook Design Framework

pedagogy. Given this, it is not surprising that researchers advocate the need for the integration of video technologies and assessment of their impact in real classroom settings. Consistent with this, the next chapter will demarcate the theoretical framework that guides the research. In combination with the video hooks, it provides the platform by which both practical and theoretical research advancements can take place through the methodology.

Chapter 4: Theoretical Framework

4.1 Introduction

The predominant goal of Design-Based Research (DBR) (the methodology employed in this study, see chapter 5) is to advance theoretical fields of understanding through adaptable and robust design models derived from research in real world contexts (Alghamdi and Li 2013, Bakker and van Eerde 2015, Dede 2005, Hoadley 2004). Such practical environments are utilised to forward theoretical considerations in making a contribution to contemporary research issues in education (McKenney and Reeves 2013). The proto-typical design model constructed (Bakker and van Eerde 2015, Edelson 2002, Flynn *et al.* 2016, Kelly *et al.* 2008) in this thesis is centred around the ‘hook design’, which was explored in the previous chapter, and ‘hook theory’ which will be delineated presently. Combined, they represent the initial proto-design model to be tested in design cycle 1.

The hook theory has been informed through a synthesis of all the pertinent literature with regard to set induction, anticipatory sets and hooks. Given this consideration, the emergent hook theory is predicated upon four broad areas of inquiry. These include; (1) the pedagogical foundation of hooks as short instructional strategies utilised at the beginning of a class with the impact as such that the hook specifically targets students’ (2) interest (Jewett Jr 2013, Marinchech 2013), (3) attention (Hunter 1994, Lemov 2010, McCauley *et al.* 2015) and (4) engagement (McCrorry 2011, Riendeau 2013). The first salient theoretical consideration to be discussed will be the use of hooks at the beginning of class. The following sections will explore the constructs of interest, attention and engagement respectively along with their theoretical convergences.

4.2 The Pedagogical Foundation of Hooks

As per the discussions in chapter two, the idea of ‘hooking’ students at the start of class is not new. However, as evidenced in the previous writing, there is limited advice, barring some simple examples in the literature with regard to how to use hook based instructional strategies in class. As a theoretical and pedagogical foundation for this research, the following will examine any instructional advice provided with regard to how and when to use a hook in class.

Historical instructional models from the 1900’s explore the notion of eliciting student attention from the start of instruction (Herbart 1901). Hook-like pedagogies continued to appear throughout various developments in instructional models with Dewey (1933) and Heiss *et al.* (1950) suggesting that an explicit exploration factor should be built into lesson introductions. This

has continued with numerous authors discussing the emergent idea of hooking at the start of class. Schuck (1969, 1970, 1981) and Perrott (1982) described set inductions as formulaic introductions to lessons. With a relevance based introduction, the set attempts to create an organising framework in lessons for a smooth transition from old knowledge to new. As part of this method, teachers are told to engage student attention, but no specific methods are suggested (Perrott 1982). In 1982, Perrott added to the set induction literature and underpinned their function as a method to focus student attention at the beginning of instruction. Following Schuck's work, the 5E model was developed in which 'engagement', the first 'E', represents the keystone feature in the process at the beginning of instruction (Bybee *et al.* 2006). Positioned at the start of class, it is noted that any engagement based activity should be short and simple. According to Bybee *et al.* (2006, p. 9) "Asking a question, defining a problem, showing a discrepant event, and acting out a problematic situation are all ways to engage the students and focus them on the instructional task." Hence, the engagement step acts as the hook for the following instruction. During a similar timeframe, in the 1980's, Keller developed the ARCS (Attention, Relevance, Confidence, Satisfaction) model of instruction. The model presents four general requirements to inspire motivation. It is designed to be a practical strategy with the first 'hook like' goal being to obtain and sustain student attention at the beginning of instruction. In 1994, Hunter wrote about anticipatory sets as a pedagogical strategy in which the teacher focuses the student's thoughts onto the learning goals of a lesson. It is a short activity that directs attention, often at the start of a lesson. It may even be used as pupils enter a room (Hunter 1994). This theme of attaining student interest and attention at the start of class continually reoccurs throughout more modern literature (Coffman 2003, Lemov 2010, Riendeau 2013, Yeo and Ting 2014) as Marinchech (2013) posits, a hook is a short introductory moment that puts the material out in front. The hook is the introduction and not the lesson (Marinchech 2013). For a hook to be successful, it has to be short and it has to be posed at the beginning of instruction (Lemov 2010). This is a pivotal step in the learning process as authors note how engaging the student from passive to interactive positions is the first step to deeper learning (Beeland 2002, Clifton and Mann 2011). Even though modern references discuss the idea of hooking and advocate the use of hooks at the start of instruction, Jewett Jr (2013, p. 442) was the first author to suggest pedagogical examples that can act as hooks in class stating that; "startling demonstrations can be used to raise student interest before moving onto the material". Indeed, this ideology of utilising mysteries as a hook at the beginning of class was expanded upon by Broggy

et al. (2014) and Dittmar *et al.* (2014) as they talk to the TEMI (Teaching Enquiry with Mysteries Incorporated) model of instruction. Expanding in the 5E model described previously, TEMI utilises the same structure, however, it employs mysteries in class as a hook for engagement (Broggy *et al.* 2014, Dittmar *et al.* 2014). The TEMI project is an international research venture which aims to harness the power of students' emotions through mysteries in science class.

As can be derived from the research into hooking methods, there is a distinct gap pertaining to structured and scaffolded pedagogical advice for educators. Examples of hooks are given in previous chapters, however, they are general and non-specific. Yet, this examination into the pedagogical foundation of hooks provides a grounding for the first phase of research. As detailed in chapter 3, a number of the hooking recommendations described above such as discrepancy (mysteries), relevance and questioning have already been built into the video hooks and form part of their proto-theoretical design. Thus, in terms of pedagogical implementation, the remaining major theoretical impart is that the hook should be used at the start of the lesson (Broggy *et al.* 2014, Bybee *et al.* 2006, Bybee 2009, Dittmar *et al.* 2014, Hunter 1994, Jewett Jr 2013, Keller 1987a, Lemov 2010, Schuck 1981). Hence, hook theory posits that any design artefact or instructional methodology created as a hook, should be employed at the beginning of a lesson. Therefore, this instructional method will be employed as the pedagogical accompaniment to the video hooks throughout the initial phase of research. This will provide a frame of reference in which its pedagogical suitability to the Irish science classroom can be thoroughly examined.

4.3 Student Impact: Interest, Attention and Engagement

As described in previous chapters, the intended impact of a successful hook employed at the start of class is predicated upon the development of interest, attention and engagement among the student body. This goal of 'hooking' had been derived from the limited amount of literature pertaining to hooks with authors utilising one of the three constructs to describe the hook impact on students. Upon examination, it seems the authors do not utilise the terms in a strict academic sense, rather in a colloquial and sometimes interchangeable manner. Yet, the literature forms the basis for the intended outcome of the physics video hooks in class per their initial design. Hence, this section will fully explore interest, attention and engagement, not as complete orthogonal constructs, as their overlap will also be theoretically investigated. With such a demarcation, this chapter will arrive at a definition of the intended hook outcome incorporating the three constructs.

This will allow the researcher to examine the student impact of the hooks in a rigorous, valid and informed manner.

4.3.1 Interest

4.3.1.1 Introduction

Interest as a psychological state is referenced on numerous occasions as a predicted outcome when utilising hooks within instruction. Dewey (1913) was the first to identify the vital role that interest plays in learning. He believed that for deep learning to occur, interest must be present in the classroom environment. He also believed that interest could be fostered. Interest, as an active state, brings individuals into contact with new knowledge and experiences that go beyond their current boundary of information and achievement (Ainley and Luntley 2007, Joseph and Nacu 2003). Characteristically, the patterns of interest represented by an individual predict future preferences and motivations of action (Krapp and Prenzel 2011) rendering it a vital trait in educational environs (Hoffmann 2002, Joseph and Nacu 2003, Krapp 2007, Sinatra *et al.* 2015).

Interest is a multidimensional construct. In psychological research, it is classically differentiated into situation and individual (personal) components (Linnenbrink-Garcia *et al.* 2010, Magner *et al.* 2014). The following will draw upon the relevant literature to illuminate both situational interest and individual interest.

4.3.1.2 Situational Interest

Situational interest is defined by Schraw *et al.* (2001, p. 211) as “temporary interest that arises spontaneously due to environmental factors such as task instruction or an engaging text”. It is the type of interest a student develops in a subject due to their surrounding environment and teacher. Given this, situational interest can be nurtured and supported in the classroom (Kerger *et al.* 2011). It is pivotal in educational settings as it aids in both learning and memory function (Flowerday *et al.* 2004).

Situational interest, similar to interest as a whole can be further broken down into triggered situational interest and maintained situational interest, often referred to as the ‘catch’ and ‘hold’ of interest respectively (Mitchell 1993, Tsai *et al.* 2008). Hidi and Baird (1986) were the first to develop a trigger-maintenance hypothesis of interest development. In 1993, Mitchell advanced this hypothesis stating that the largest quandary within interest literature was the lack of an adequate

model. In light of this, the author set out to empirically design a model of situational interest that could be applied to the secondary mathematics classroom. He developed the catch and hold model displayed in figure 4.1 (Mitchell 1993).

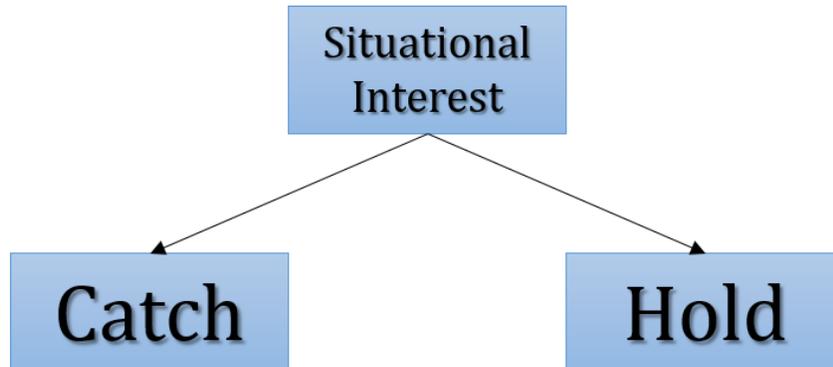


Figure 4.1: Situational interest and the two components of the ‘catch’ and ‘hold’ as defined by Mitchell (1993)

The triggered aspect (catch) of situational interest usually occurs when students report their excitement immediately or during a specific intervention (Palmer 2004). This refers to an altering of the physiological state that is co-ordinated in short term affective and cognitive processing. Generally, but not exclusively, it is externally supported (Hidi and Renninger 2006). The triggering of situational interest can initiate cognitive activation and allow for successful learning as this form of interest allows for focused attention (Magner *et al.* 2014). In fact, Linnenbrink-Garcia *et al.* (2010) conceptualise triggered situational interest as the process of grabbing attention, a sentiment that is agreed upon in the wider literature (Bergin 1999, Magner *et al.* 2014). Triggering is achieved by variables that initially stimulate pupils to become interested (Lavonen *et al.* 2005). Mitchell (1993) notes that group work, puzzles and technology can all act as triggers for interest. However, the author comments in a similar fashion to Keller (1987b, 2000, 2004), that aspects of instruction which simply catch interest can be regarded as ‘gimmicks’ with little educational value. It is positioned that the triggered interest must be maintained (hold) throughout instruction for it to be of benefit to students (Mitchell 1993).

Triggered and maintained situational interest run on a continuum and it is advised by Lavonen *et al.* (2005) that effective instruction moves students onto the maintained phase as it is

the key factor that encourages learning. Maintained situational interest (hold) is a more involved form of interest whereby “individuals begin to forge a meaningful connection with the content of the material and realise its deeper significance” (Linnenbrink-Garcia *et al.* 2010, p. 2). This phase is exemplified by persistence over an extended period of time (Hidi and Renninger 2006). To maintain situational interest, the specific content has to be meaningful and important to the learner through a value laden component of instruction (Hidi and Renninger 2006, Magner *et al.* 2014, Mitchell 1993). Given this, meaningful and relevant learning conditions are paramount to maintained situational interest (Lavonen *et al.* 2005).

According to Hidi and Renninger (2006), the maintained interest phase may be a precursor to individual interest. This is the next form of interest in which there is the appearance of a relatively stable predisposition to seek repeated engagement over time. The authors state that situational and individual interest run on a continuum and the two traits are interlinked. It is positioned within the literature that repeated exposure to situational interest will eventually lead to the development of an emergent individual interest among learners (Bergin 1999, Hulleman and Harackiewicz 2009, Krapp 2007, Linnenbrink-Garcia *et al.* 2010, Palmer 2009). Linnenbrink-Garcia *et al.* (2010, p. 3) discuss the link between the two constructs;

“Maintained-SI provides the link between triggered-SI and individual interest. Once students hone in on the course material (triggered-SI), those who view it as enjoyable and meaningful (maintained-SI) are likely to value the material beyond the context of that particular course and may seek out new opportunities to have contact with the domain and expand their knowledge. It is through this transformation of maintained-SI that individual interest is thought to develop”.

This passage highlights the pivotal nature of situational interest as a starting point for individual interest. The process of developing interest runs on continuum with individual interest being the end goal. This will be outlined presently.

4.3.1.3 Individual Interest

Individual (personal) interest is created from an enduring personal value. It is less spontaneous than other forms of interest and is activated internally (Bergin 1999). Individual interest develops slowly and is an enduring predisposition or preference to re-engage with specific content (Lavonen

et al. 2005, Linnenbrink-Garcia *et al.* 2010, Subramaniam 2009) Hidi and Renninger (2006) designed the four-phase model of interest development based on existing research (Figure 4.2). The model is comprised of four phases including the triggering/maintenance phase as a grounding for emergent individual interest and a well-developed individual interest. The model represents situational and individual interests in terms of cognitive and affective processes. It is built on the basis that situational interest serves as a base for the manifestation of individual interest. Early phases consist of focused attention and positive feeling. Later phases consist of knowledge and positive feeling. Emergent individual interest is characterised by stored knowledge and positive feeling. Based on previous task engagement, the learner will now opt to perform the task over resisting it as they generate their own curiosity and interest internally. Furthermore, the pupil is more likely to persist with difficult questions and be more resourceful in tackling problems. This interest is now typically self-generated as opposed to the situational steps that were externally supported (Hidi and Renninger 2006). The final phase is a well-developed individual interest that is sustained over a vast amount of time. It is distinguished by the pupil's value of the knowledge. This enables the learner to process information more quickly and anticipate problems. A well-rounded comprehension of strategies in the domain and self-regulation typify their interest. Again, it is usually internally generated (Hidi and Renninger 2006).

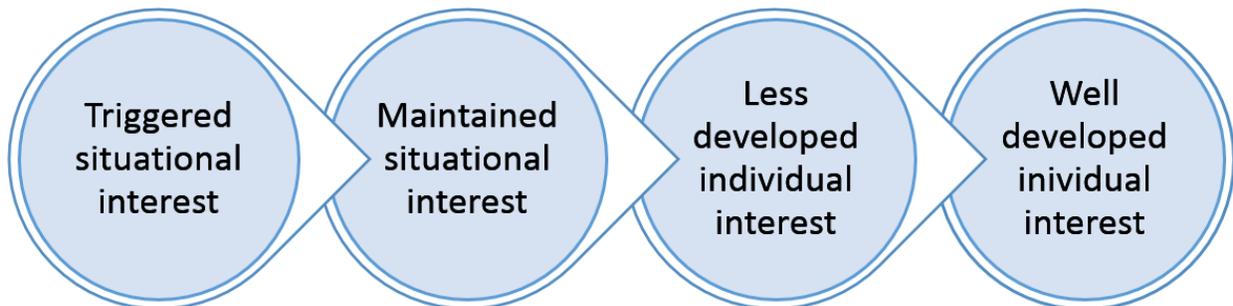


Figure 4.2: Hidi and Renninger's (2006) four-phase model of interest development

From the theoretical grounding of interest as a malleable construct in the classroom, it is apparent that situational interest should be a key focus of any hook based intervention. Both situational and individual interest are wholly relevant to education, but situational interest is malleable in the short term by teachers (Bergin 1999, Schraw *et al.* 2001). Situational interest can be triggered or maintained and eventually lead to individual interest. It can therefore be the potential start of a

personal learning journey. Thus, the focus of this research with regard to interest will be on the development of situational interest in science class through the use of hooks.

4.3.2 Interest and Curiosity

Emanating from a review of the literature surrounding interest, a considerable amount of overlap was found between interest and curiosity. The argument can be constructed that the modern theoretical derivations of interest, in particular situational interest, are heavily influenced by research into curiosity (Kashdan and Silvia 2009).

Silvia (2008, p. 57) denotes interest as “the curious emotion”. Curiosity can be a powerful motivator of behaviour. It is a basic mechanism, enabled through intelligent animals to master their particular context (Arnone *et al.* 2011). Arnone *et al.* (2011) defines curiosity as a construct that is concomitant with interest development. This is particularly apparent in the first occurrence of triggered situational interest that can be characterised by curious and exploratory behaviour (Flowerday *et al.* 2004, Krapp 2007). Such exploration is driven by a need for competence and completeness in one’s own mind (Arnone *et al.* 2011).

From the previous sentiments, it can be discerned that the triggered phase of situational interest is often characterised by curiosity. The question remains, however, what events precipitate curiosity generated situational interest? Curiosity is described by Shenaar-Golan and Gutman (2013) as an ambiguity between new and previous knowledge, evoked through complexity, novelty and unfamiliarity. This leads the discussion onto ‘epistemic curiosity’ which is a type of curiosity developed as students encounter new information. Discrepant instruction has the capacity to yield uncertainty among learners. This reveals an ‘information-gap’ in their cognitive schema, a term originally coined by Berlyne (1966). By definition, epistemic curiosity is the drive to acquire new knowledge with associated positive feelings through interest or to reduce an undesirable state of information deprivation (Litman *et al.* 2005, Litman *et al.* 2010). Jirout and Klahr (2012) label the provocation of an information gap as an ‘unpleasant arousal’, a condition in which the learner is motivated to reduce the negative sensation. The deprivation, in essence, refers to a gap in learners’ knowledge which they desire to fill through “information seeking behaviours” (Rotgans and Schmidt 2011, p. 65). More modern interpretations of the phenomena label it as a knowledge gap (Jirout and Klahr 2012) or deficit (Rotgans and Schmidt 2014). Indeed, Rotgans and Schmidt (2014) refer to situational interest and epistemic curiosity as the same construct. They posit that situational interest is a response to a perceived knowledge deficit. It is

triggered when an individual in an environment is cognisant of a new problem (Rotgans and Schmidt 2014). Therefore, there seems to be strong links between situational interest and curiosity as a motivator for exploratory behaviour. However, this type of behaviour is seemingly connected to discrepant events or the creation of a knowledge gap/deficit. As noted in the previous chapter, discrepancy is a key part of the video hook design. In light of this, epistemic curiosity may be an integral trait observed in classrooms throughout interventions. Hence, its inclusion in the theoretical framework.

4.3.3 Attention

As noted by a number of authors (Hunter 1994, Lemov 2010), attention is a core trait concomitant with hook instructional strategies. Attention refers to the selection of stimuli through the preponderant control of behaviour (Berlyne and Ditkofsky 1976) and is a necessary precursor to information processing (Anderman *et al.* 2004). It is a multifaceted phenomenon requiring the whole brain working as a single entity (Desimone 2007). It is directly related to human performance and facilitates the focusing of the conscious mind (Ainley and Luntley 2007). Successful allocation of attention, gives way to fluid information processing by reducing interferences (Rosengrant *et al.* 2012). A smooth processing is akin to a sense of flow whereby an individual is fully engaged with an activity, often accompanied by a sense of intrinsic enjoyment (Eastwood *et al.* 2012). The deeper we process information on a cognitive level, the more attention we pay and this translates to better learning (Heath 2009). Indeed, McCrory (2011) and Jensen (2008) state that it is a necessary condition for learning and achievement. Given this, attention is a vital component of successful educational environments. Efforts within instruction should therefore attempt to create an attention aware classroom (McVay and Kane 2012).

The process of paying attention means that one orientates, engages and maintains their neural network while also suppressing distractions (Grossberg 1995). By its nature, it is a highly-disciplined state (Jensen 2008). Attention processes act as a filter and direct learning capacities toward important information rather than the deluge of competing sensory stimuli present at any one time (Desimone 2007, McCrory 2011). In achieving a focused state of attention (Ainley and Luntley 2007), both consciousness and attention occur in levels that impact on each other in an upward spiral. Consistent with this, Risko *et al.* (2012, p. 234) elucidate that the “attentional state is dynamic, fluctuating in time from points of intense focus to total disengagement”. Therefore, there are grades of attention. Working through the milieu of signals one encounters on a daily

basis, much of which is irrelevant, the human mind unconsciously and consciously selects the information that will be processed (Cosman and Vecera 2012). This is controlled by the relevance of a task, something that is directly personal and pertinent to the learner. This forms a ‘target’ in their active memory. Certain stimuli will make people pay attention depending on the situation. Where relevance is present, the feature ‘pops out’ to the learner. This relevance becomes the salient property that grasps and holds attention (Cosman and Vecera 2012).

Based on the above, the physics video hooks have to represent a relevant and salient feature of instruction to both attain and maintain student attention. Attention is a foundational construct preceding effective instruction (Young *et al.* 2009) making it a keystone feature of the hooking process.

4.3.4 Engagement

The final construct pertaining to hooks is that of engagement. In terms of engagement, a distinction needs to be made between school engagement and engagement in learning (Fredricks *et al.* 2005, Harris 2011). This research is focused on engagement in learning grounded in the classroom context (Bain 2004) as this type of engagement is deemed to be malleable through pedagogical interaction (Fredricks *et al.* 2004).

Engagement is regarded as a persistent and affective motivational state characterised by vigour and dedication (Wefald and Downey 2009). Today, it is probably the most thrown about word in modern education (Bain 2004) and one of the hottest topics in terms of educational psychology (Sinatra *et al.* 2015). The rationale is that engagement is one of the most vital factors in encouraging students to learn (Beeland 2002, Rotgans and Schmidt 2011c). Students who are engaged show augmented productivity and capacity for continuous knowledge acquisition (Carini *et al.* 2006).

With so much research into the area of engagement, it has become a multifarious construct with little agreement in the literature pertaining to a definition or effective measure (Sinatra *et al.* 2015). However, the majority of the literature has rested on a model with emotional, cognitive and behavioural facets (Fredricks *et al.* 2004, Fredricks and McColskey 2012, Hampden-Thompson and Bennett 2013). The unification of behaviour, emotion and cognition has created a meta-definition of engagement (Fredricks and McColskey 2012) as the individual constructs are inadequate as definitions of engagement on their own. The conceptualisation of engagement is not

agreed upon by all authors, however, the tripartite theoretical system has approached the forefront of engagement research (Li and Lerner 2013). The following sections will elaborate upon emotional, cognitive and behavioural engagement respectively as they may be observed traits in the hook classroom.

4.3.4.1 Emotional Engagement

Emotional engagement refers to the affective reactions of students in the classroom (Fredricks *et al.* 2004, Hampden-Thompson and Bennett 2013, Li and Lerner 2013, McCrory 2011). It encompasses reactions to instruction in either a positive or negative manner (Fredricks *et al.* 2004). According to McCrory (2011), there is a wide range of emotions that teachers can foster throughout their teaching. Curiosity, anticipation, uncertainty, surprise, understanding, wonder and amazement are components of good teaching that give pupils an emotional reward linked to the topic. Such positive feelings in class have been found between emotional engagement and achievement (Sinatra *et al.* 2015). It is suggested by Hampden-Thompson and Bennett (2013) that these emotions experienced in class add meaning and potentially a deep value to the lesson content (Fredricks *et al.* 2004) rendering emotion as a pivotal factor in engaging students.

4.3.4.2 Cognitive Engagement

Cognitive engagement is a psychological construct in which mental effort is expended on an academic task (Sinatra *et al.* 2015, Li and Lerner 2013). It is characterised by persistence to understand a topic over a period of time (Rotgans and Schmidt 2011c). Cognitive engagement incorporates cognitive activities commensurate with the lesson. The deeper a student processes information, the more likely it remains intact for future memory retrieval. The shallower one's processing, the more likely information will be forgotten. The words 'deep' and 'shallow' describe a continuum of levels ranging from intensive learning to surface processing. Cognitive engagement, therefore should result in the construction of mental models of memory (Gilbert 2005). Authors continually note that cognitive engagement comprises of self-investment (Appleton *et al.* 2006, Fredricks *et al.* 2004). It is recognised in class when students expend mental effort upon encountering learning tasks. It is often represented by persistence (Zhu *et al.* 2009) in attempting to understand or master skills (Fredricks *et al.* 2004).

4.3.4.3 Behavioural Engagement

Behavioural engagement revolves around the idea of active participation in class (Fredricks *et al.* 2004, Li and Lerner 2013). Within a lesson, it concerns partaking in learning and includes behaviours such as persistence, attention and asking questions (Fredricks *et al.* 2004). Behavioural engagement is observable in the classroom and is defined by voluntary (Appleton *et al.* 2006) active behaviours such as asking and answering questions, writing and listening (Lan *et al.* 2009). It also refers to concentration, effort and persistence within instructional situations (Fredricks *et al.* 2004).

4.3.4.4 Defining Engagement

As can be derived from the discussion above, there is considerable overlap between emotional, cognitive and behavioural engagement. This is consistent with what authors state in the literature (Fredricks *et al.* 2004, Li and Lerner 2013, Sinatra *et al.* 2015). Sinatra *et al.* (2015) argues that the three constructs cannot be effectively distinguished as there is so much interweaving between them (Sinatra *et al.* 2015). The authors give an example of the interconnected nature of the three engagement factors with an illustration of a teenager reading a vampire novel.

“a teen can be fully engrossed in reading the latest vampire novel. One could consider the cognitive, emotional, and behavioural dimensions to engagement in this literacy experience. The cognitive aspects would be wondering how vampires survive on only blood; the emotional aspects might include the emotional response to the characters such as empathy for the victims or fear of the vampires. The behavioural component might include staying up late at night to finish a chapter and choosing to discuss the book with a friend” (Sinatra *et al.* 2015, p. 4).

In the above scenario, engagement is a meta definition with the three constructs potentially present in a separate but interwoven manner. Taking this into account, this research must be aware of the interplay between individual engagement constructs and how they may direct/impact each other in a classroom context. One or all of the constructs may be readily observed in class and engagement as a construct will have to be navigated based on the data generated.

4.4 Interplay between Constructs

Within the pertinent literature, there is a considerable amount of theoretical convergence between the three constructs of interest, attention and engagement. This overlap will be fully demarcated presently as observed trends in the classroom can potentially be informed by or advance current theoretical positions.

4.4.1 Attention and Interest

With regard to interest and attention, numerous authors indicate that the former construct is mediated by attention (Ainley *et al.* 2002, Arnone *et al.* 2011, Hidi 1990, Hidi 2006, Krapp 2002, Linnenbrink-Garcia *et al.* 2010, Mazer 2013, Peters *et al.* 2009, Rotgans and Schmidt 2011c, Silvia 2008). Krapp (1999) suggests that learning from being interested is due to the selective (Hidi 1990) allocation of attention. Hidi *et al.* (2004) expands on this by suggesting that interest is a state in which one gives automated attention. With such a definition, it is implied that attention is a condition for interest. Other authors add to the debate and position attention as a construct more closely aligned with situational interest as opposed to interest as a whole. Palmer (2009) posits that situational interest is a short term form of focused attention within a specific context. As previously discussed, situational interest is spontaneous and environmentally activated (Flowerday and Shell 2015). It is described by Flowerday and Shell (2015, p. 135) as “instrumental in catching attention”. However, according to Linnenbrink-Garcia *et al.* (2010), student attention is equivocal to triggering situational interest as opposed to situational interest as a whole with maintained facets. It can be derived from the literature that many authors recognise interest as a condition that is mediated by augmented attention levels. However, the same argument can be applied to the literature surrounding engagement.

4.4.2 Attention and Engagement

Similar to the interaction between interest and attention, many authors recognise the link between engagement and attention (Fredricks *et al.* 2004, Gilbert 2005, Heath 2009, Jones *et al.* 2015, Peters *et al.* 2009, Sinatra *et al.* 2015). According to Heath (2009), the basic definition of engagement is to hold attention. Gilbert (2005, p. 49) adds to this argument by stating that “engagement implies extended focus and thought on a topic”. Attention is seen as a necessary precursor to even the slightest forms of engagement (Peters *et al.* 2009). Whereas, sustained attention is warranted for the development of longer term engagement (Peters *et al.* 2009). Jones *et al.* (2015) expands on this and states that attention allocation is a trigger for engagement. In

more specific terms, Sinatra *et al.* (2015) states that attention can also be seen as a form of behavioural engagement with content, especially if there are visual signs of extra eye contact or leaning forward during class (Sinatra *et al.* 2015, Fredricks *et al.* 2004). With this, observed behaviour can be utilised as an indicator of both attention (Eastwood *et al.* 2012) and engagement in class.

4.4.3 Interest and Engagement

In light of the previous paragraphs, the authors denote attention as an observable trait concomitant with interest and engagement. Yet, Renninger and Bachrach (2015) talk to attention as being a trait aligned with the initiation or triggering of interest and engagement. The authors claim that both interest and engagement can be triggered by something catching the attention of learners. They state that the triggering of interest establishes the initiation of engagement. (Renninger and Bachrach 2015). This brings up the theoretical linkages between interest and engagement that are heavily referenced in the literature. Studies in terms of interest and engagement are almost entirely distinct even though many authors speak of interest in terms of engagement and vice versa (Renninger and Bachrach 2015). The overlap between the constructs will be explored currently.

Interest and engagement are often described as related traits (Arnone *et al.* 2011, Flowerday *et al.* 2004, Flowerday and Shell 2015, Linvill 2014, Magner *et al.* 2014, Palmer 2004, Renninger and Bachrach 2015, Zhu 2014). Sun and Rueda (2012) suggest that situational interest is associated with the three types of engagement (emotional, cognitive and behavioural), with emotional engagement being the most strongly correlated (Sun and Rueda 2012). The wider literature tends to describe interest as a type of emotional engagement (Fredricks *et al.* 2004, Harris 2011, Köller *et al.* 2001, Sinatra *et al.* 2015, Trumper 2006). Whereas some authors would describe interest as a trait that increases emotional and cognitive engagement (Dohn 2013, McCrory 2011, Schraw and Lehman 2001).

In terms of emotional engagement, it is posited that interest is an emotion that determines engagement (Fredricks *et al.* 2004, Sinatra *et al.* 2015, Hampden-Thompson and Bennett 2013). Köller *et al.* (2001, p. 449) conceptualises interest as a “person-object relation that is characterised by value commitment and positive emotional valances”. Such positive emotional valances are often used to describe interest and frame it as a type of affective engagement with content (Arnone *et al.* 2011, Subramaniam 2009, Harris 2011, Rotgans and Schmidt 2011).

However, Hidi and Harackiewicz (2000) postulate that interest is a disposition that crosses the boundary between the cognitive and emotional domains. Krapp (1999) agrees and states that interest is characterised by affective (emotional) (Arnone *et al.* 2011) and cognitive components (Krapp 1999). In another publication, the author states that situational interest is a psychological state that “involves focused attention, increased cognitive functioning, persistence and affective involvement” (Krapp 2002, p. 388). More recently, this has been reiterated by McCrory (2011) and Dohn (2013) who denote situational interest as having both cognitive and affective components.

The theories presented are conflicting to a point, however, the thesis must be open to all theoretical possibilities. Evidence generated will be assessed in light of both ideologies with regard to the connections between interest and engagement. Indeed, this thesis is taking account of all the literature with regard to the three constructs of attention, interest and engagement. The focus at this point is to remain open to ancillary conditions so as to attain a balanced insight into what actually happens in the classroom when students interact with the hook. Therefore, the initial phase of research will investigate attention, interest and engagement as separate concepts, however, the theoretical overlap described above will be utilised as a key reference if interplay between constructs presents itself in the natural context of the classroom.

4.5 Defining Constructs for the Purposes of this Research

This chapter has set about to theoretically explore hooks in terms of their pedagogical foundations and their predicted impact on students. Pertaining to such impacts, the three constructs of interest, attention and engagement have been explored. The delineation within this chapter will be utilised as a definition for future reference. In sum, the theoretical exploration of the hook impact will be used as a foundational backdrop to inform the student impact of the physics video hooks in class that is derived from data collection. If appropriate, this data will be linked back to the three constructs, however ancillary conditions may arise and the research agenda must remain open to such developments. The student impact will be described in terms of the pedagogy observed in class along with their interaction with the various content in the hook design.

Based on this, the theoretical model being employed in the first stages of this research is displayed in figure 4.3. It encompasses both design and theory through the simultaneous advancement of the physics video hooks and hook theory.

The left rectangle represents the combined design and theoretical impart of chapter 3 and 4 respectively. The remaining boxes to the right represent the constructs of interest, attention and engagement. Based on theory, this is the intended student impact of hook based pedagogies. As such, they will be investigated in light of the current chapter.

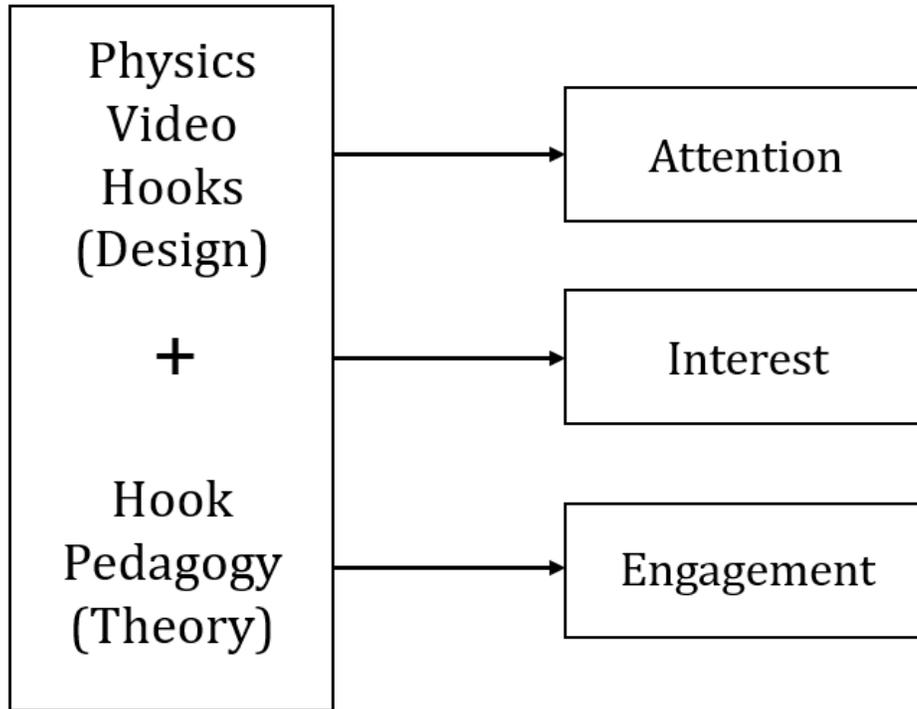


Figure 4.3: Proto-Theoretical model of hooks mediated by the hook design, pedagogy and student impact

4.6 Chapter Summary

Pertaining to the impact of the hooks, although there are multiple theoretical interrelationships between interest, attention and engagement, during the first phase of this research, the constructs will be investigated separately. Research data from interviews and observations will then be utilised to determine if any overlap between constructs in the classroom context should be established or if constructs should be removed or auxiliary conditions added (Renninger and Bachrach 2015). For example, students may be quiet during the video hook, which could be represented as an indicator of attention however, there may be no evidence that points to the manifestation of interest or engagement. Such a strategy is being employed to assess the constructs in an open and rigorous manner, while also not pigeonholing the research agenda based on the

Chapter 4: Theoretical Framework

previously described theoretical relationships. Employing a DBR methodology that is grounded in the classroom context, the student impact will be derived from visible reactions observed by both the researcher and teacher participants. Furthermore, the interaction between the students, video hook and teachers will inform the development of constructs in a natural classroom environment, something that is lacking in the current literature (Krapp 2002, Lavonen *et al.* 2005, Renninger and Bachrach 2015). Therefore, due to the nascent nature of research into hooking, the initial qualitative (see chapter 5) research approach will remain open, iterative and flexible. Thus, the student impact will be informed by, but not limited to the defined theoretical ideologies presented in this chapter.

The next chapter articulates the methodology employed throughout this research, informed by the key relevant theories presented in this chapter, it presents a robust methodological framework aimed at generating new and novel data pertaining to hooking within science classrooms.

Chapter 5: Methodology

5.1 Chapter Introduction

Methodology refers to the political, theoretical and philosophical background to social research and associated implications for practice and the use of particular methods (Cohen *et al.* 2011). Methods, refers to explicit techniques used to obtain and analyse data to create further knowledge. Hence, methodology “is a strategy of enquiry that guides a set of procedures” (Petty *et al.* 2012b, p. 378). This chapter sets out and describes the philosophical base behind the research along with the research strategy and methods that are used to answer the thesis’ research questions. The methodology is demarcated in a step by step approach with appropriate critique. The rationale and justifications behind choosing said methods will be explored presently. Potential limitations are noted with associated compensatory strategies. In addition, methodological approaches are illustrated with examples to highlight the suitability of choices.

The specific research strategy embodies a qualitative Design-Based Research (DBR) approach based on three design cycles or iterations. The rationale behind this decision in terms of suitability is also outlined in this chapter.

5.1.1 Characterising the Problem

The research addresses a primary research question which can be broken down into subsidiary questions. The primary research question is: How can physics video hooks be designed and implemented to generate student attention, interest and engagement in physics?

The supporting question which helps answer the primary question has two parts: (a) Does teaching with video hooks target junior science students’ attention, interest and engagement in physics lessons? And (b), if so: what are the integral components of physics video hooks from both technological and pedagogical design perspectives that shape the development of student attention, interest and engagement?

Research objectives that work in tandem with the research questions can be divided into three principal aspects: pedagogy, student impact and design. Pedagogy refers to designing a teaching methodology that is effective and complementary to hooks. The student impact refers to how students observe and interact with the hooks. Hooks are designed to augment attention, interest and engagement among students. Finally, the design of the hooks will be examined. The hooks were constructed with a modified instructional design process that incorporated multimedia

and cognitive load theories. In addition, multiple embedded design elements were utilised to foster attention, interest and engagement among students.

The key word in the research questions is ‘does’. The research presents the specific challenge of understanding physics video hooks in a real classroom setting. Therefore, the challenge is examining if hooks ‘work’ in the Irish junior science classroom. Do the hooks achieve what they were designed for and secondarily how are they used by Irish junior science teachers to maximise their potential impact?

5.1.2 Philosophical Stance of the Researcher

This research is exploratory as a minimal amount of research into video hooks has been conducted previously. This produced the quandary of what methods would be most effective to answer the research questions and objectives. Often, the choice of method is set out by the philosophical stance of the researcher or the paradigm of the research. A paradigm is a basic set of beliefs that determine one’s worldview. Such beliefs set out the nature of the world (Guba and Lincoln 1994, Mack 2010). The choice of paradigm sets out the motivations and expectancies of research. It is the philosophical intent behind a study. It embraces ‘knowledge claims’ and an individual’s perceptions pertaining to epistemology and ontology (Mackenzie and Knipe 2006). One’s view of reality and the perceived real world is their ontology. Whereas, epistemology refers to how one acquires knowledge or believes knowledge is created. Both ontology and epistemology combine to represent a paradigm. Mack (2010, p. 6) posits why this is relevant to research by stating “the researcher’s intentions, goals and philosophical assumptions are inexplicably linked with the research they do”. Hence, how a researcher defines reality and knowledge determines how they will evaluate research (Mack 2010).

Being a science teacher, I come from a heavily positivistic background. Positivism is akin to the scientific method of quantitative inquiry that emerged during the enlightenment of the 18th century (Cohen *et al.* 2011). From an ontological perspective, it assumes an objective reality (Petty *et al.* 2012a). Positivism assumes that an understandable and measurable reality exists. Knowledge is summarised in terms of “time and context free generalisations” (Guba and Lincoln 1994, p. 109). Social reality is examined from a cause and effect perspective based on events. Hence, the cause of human behaviour is external (Mackenzie and Knipe 2006). Knowledge of this reality or

epistemology is constructed via observation as whatever can be observed is real. Positivism assumes that humans can be observed and measured by such laws (Petty *et al.* 2012b).

Criticism of positivist methods came from the post positivist movement which state scientific methods should not be used to research human affairs (Mack 2010). Causal links that may be present in natural science cannot be established in the complexity of scenarios in which humans construct their own meaning (Mack 2010). I would agree with Mack (2010). Yet, I believe that there is a real world that can be subject to empirical checks. However, such empirical checking is imperfect due to human interactions with reality. I also postulate that the human world is different to the real world and cannot be measured by positivistic approaches. This is highlighted in the science classroom and in my teaching in a number of ways. One of the best examples is when examining onion cells under the microscope with students, one of their tasks is to draw what they have observed. Under a positivistic stance, all drawings should be similar with the same aspects highlighted. However, drawings are always disparate with huge variation in detail, size and colour. The students viewed the same phenomena, but interacted and observed it differently. Humans in this sense, are complex and not measurable through numerical and simplistic means. Therefore, ontologically I posit that there is a set reality, however, epistemologically I originate from an interpretivist/constructivist perspective.

This in a sense is a rejection of positivistic views and aligns with alternative approaches to positivism which may have differing epistemologies, but are united in their rejection of positivism (Cohen *et al.* 2011, Mack 2010). A social world can only be understood from the viewpoint of those that inhabit that world. The participants themselves define social reality (Cohen *et al.* 2011, Gall *et al.* 2007). Within such an interpretivist paradigm, it is impossible to separate individuals and the society around them. To develop a clear understanding in research, knowledge of both is warranted (Mackenzie and Knipe 2006). How a person defines an event is seen as their own construction of reality. People create their own meanings in everyday activity (O'Donoghue 2006, Petty *et al.* 2012a). This constitutes a rejection of positivism and has led to the ontological viewpoint of post-positivism.

One of the many viewpoints of post-positivism is that of critical realism. From an ontological perspective, critical realism assumes a transcendental realist ontology with an interpretivist epistemology (Wahyuni 2012). It states that reality can only be comprehended

imperfectly due to flawed human mechanism of observation (Guba and Lincoln 1994). Within the social sciences, the aim is to elicit the emic view to determine meanings with a context (Fairclough 2005). It posits that there is a real world out there. However, garnering a full understanding of this world is impossible as humans can only ever interpret the world in an imperfect manner (Easton 2010). The critical realist recognises that observation is fallible, has error and that all theory is revisable. Hence, the critical realist is ‘critical’ of the human capability to know reality with certainty (Alvesson and Sköldberg 2009). A critical realist believes that the goal of science is to continually increase our knowledge of reality, even though we can never fully achieve that goal. Under this paradigmatic umbrella, scientific endeavours are an ongoing process (Krauss 2005). It is an incremental progression of measurement that generally relies on multiples sources of evidence as all measurement is imperfect. This is due to the ideology that observations are theory-laden and all humans are inherently biased by their cultural experiences and world views. Objectivity can only be constructed using a number of people’s perspectives, thus, objectivity is a social construct. Therefore, critical theory encompasses aspects of both positivism and constructivism. This is why critical realism can employ both quantitative and qualitative techniques as the human world and physical world are seen dissimilarly (Krauss 2005). Hence, they require different research methodologies to be appropriately examined (Alvesson and Sköldberg 2009).

As noted before, critical realism is tolerant in terms of research methods (Easton 2010). This is highlighted by Mingers *et al.* (2013, p. 795) who states that critical realism “accepts the existence of different types of objects of knowledge physical, social, and conceptual which have different ontological and epistemological characteristics.” Thus, a wide variety of research methods are applicable. However, critical realism is most suited towards research that has clearly bounded complex phenomena (Easton 2010).

Based on the above and the researcher’s philosophical standpoint, the research will adopt a critical realist theoretical underpinning. As stated, it is open to methodological techniques. However, the research questions are concerned with people, their interpretations and thoughts directed toward phenomena. The sheer complexity of educational settings and classrooms is widely agreed upon by several authors (Elton-Chalcraft *et al.* 2008, Hutchinson 1999, Mack 2010, Yin 2014). Almost every educational system is different. They are a complex web of moving parts (Elton-Chalcraft *et al.* 2008, Stake 2013). This is an inherent inhibitor when applying quantitative

methodologies to complex scenarios involving human learning (Cohen *et al.* 2011). In view of the focus of the investigation and key research questions, the study will adopt a qualitative approach that will be fully delineated in the following two sections (5.2, 5.3).

5.2 Methodological Requirements

When choosing a methodology, the approach that warrants selection is the one that can answer all aspects of the research questions. In deciding the choice of methods, an exploratory approach was employed via an analysis of literature. Based on the critical realist stance of the research, a pragmatic approach can be used pertaining to methodological considerations (Mingers *et al.* 2004, Easton 2010). Hence, both qualitative and quantitative methods can be employed either in singular or mixed methods fashion.

5.2.1 Methodological Approach

Research can be very broadly placed into quantitative and qualitative domains (Petty *et al.* 2012a). Within research they are often seen as black or white (Cohen *et al.* 2011). Quantitative approaches align with positivistic backgrounds, while qualitative approaches align with constructivist/interpretive ones (Cohen *et al.* 2011). Critical mass between the two is abound and is described by Cohen *et al.* (2011) as the paradigm wars. Since this project is exploratory and little research has been carried out in the area of hook design and implementation, the initial assessment for the methodology examined qualitative and quantitative methods or potential combination thereof. Again, this aligns with the philosophical underpinnings of this research. There were a number of factors to be considered when making methodological decisions which will be delineated presently.

Educational innovation and research has typically been forced down a quantitative route with assessments being correlational or outcome based. Neither of which lends support for innovation, rather they systematise the educational environment into readily measurable variables. A typical example of a research question is presented by Bereiter (2002, p. 323) “Does IQ correlate with the scores on a creativity test?” The only way to answer such questions is through restricting the limitations of the study so it ‘fits’ and experimental design (Bereiter 2002). Adding to this debate, it is positioned by Lather (2010) that practitioners rarely alter their teaching based upon the dominant paradigm of scientific, empirical research. Furthermore, Kozma (1991) posits that research into how instructional technology works in synergy with the learner is dependent on how

the learner constructs knowledge in their environment. In this way, learning is situated within the classroom and is anchored to the technology. They are inextricably linked and cannot be divided. Henceforth, empirical research with an emphasis on prediction and modelling will not ‘fit’ the messiness of the classrooms that require examination in this research. Within an authentic setting it is impossible to ensure that the treatment is exactly the same across groups (Hoadley 2004). Experimental control in a classroom is difficult and due to the milieu of random variables, such environments are concomitant with an inherent “resistance to experimental control” (Collins *et al.* 2004, p. 16).

In alignment, the previous argument of taking a scientific approach to the research has the potential for redundancy. Hooks have a number of separate constructs, namely, attention, interest and engagement. These three constructs can be further broken down into more specific items such as situational interest, individual interest, cognitive engagement, emotional engagement and behavioural engagement. All of which also have chronological aspects. This makes hook assessment via standardised quantitative methods complicated and inefficient. Lather (2010) argues that evidenced based scientific research in education oversimplifies the complex quandaries of teaching and learning. There is a lack of uniformity particularly when considering the variations among teachers, classrooms and contexts that are noted by numerous authors as complex and not suited to quantitative methods (Cohen *et al.* 2011, Devetak *et al.* 2010, Easton 2010, Ryan *et al.* 2007, Spencer and Britain 2003). Cohen *et al.* (2011, p. 17) asserts that positivism is weak in the immense complexity of social realms and “this point is nowhere more apparent than in the contexts of classroom and school where the problems of teaching, learning and human interaction present the positivistic researcher with a mammoth challenge”.

Additionally, an examination of scales for interest (Köller *et al.* 2001, Mitchell 1993), engagement (Wilson and Korn 2007) and attitudes (Afari *et al.* 2013, Kind *et al.* 2007) indicated that new scales would have to be developed to fully assess hooks and that is not within the remit of this PhD. Furthermore, this would not take into account the construct of attention, which is generally measured with eye tracking software (Duchowski 2007). Achievement and retention instruments (Köller *et al.* 2001, Papastergiou 2009) were also examined, however, the links between interest and achievement are not fully agreed upon (Köller *et al.* 2001, Schraw *et al.* 2001). Furthermore, hooks potentially have both short and long term elements so any quantitative assessment would have to assess a number of points in time and examine changes in responses.

Based on the above arguments, the research questions and novelty of the project, a quantitative approach was not adopted as a whole or part of this study. A qualitative approach has been selected. A fully demarcated justification is illustrated in the following section.

5.3 Qualitative Approach

In light of the complexity of the research, an interpretive paradigm with an eclectic qualitative approach will be instigated as it allows for experimentation in complex social constructs (Ryan *et al.* 2007). Fostering dialogue and opinions through naturalistic research methods will be central to the project. Additionally, it is expected throughout the study, that ancillary conditions may become central to the methodology and/or results (Cobb *et al.* 2003). The following segment will discuss qualitative approaches, their application and criticisms.

Qualitative research regarding its ontological and epistemological foundation is not a consistent phenomenon. Nor are its methodological approaches that are generally unstructured. It consists of a plethora of research techniques, including life history, action research, case study, interviews etc. each with multiple layers of background complexity (Devetak *et al.* 2010). In this way, qualitative research looks to examine lived experience of humans in context via analysis of text over numerical based approaches. It aims to generate understanding and uses the researcher as an instrument through which knowledge is constructed (Petty *et al.* 2012a). The research process collects verbally narrated material. Words are more valued than numbers, thus, providing for unique and idiographic accounts of events in situ (Cohen *et al.* 2011). This aids in creating a holistic and naturalistic approach in which researchers build up complex portraits by conducting work in human habitats (Petty *et al.* 2012a). Qualitative researchers are not so interested in the frequency of events, rather the ‘why’ and ‘how’ of an activity, group, material or situation (Spencer and Britain 2003). As such, projects tend to be exploratory with an inductive and interpretive approach (Devetak *et al.* 2010).

5.3.1 Iterative Qualitative Design

Based on the former arguments, the study will adopt an iterative qualitative design. Qualitative research is emergent in nature (Cohen *et al.* 2011). It captures rich and complex data that is mainly inductive in its processes (Spencer and Britain 2003). Therefore, the research will flow or evolve over the process of data collection. It is typical of qualitative researchers to make initial assessments of data during the collection phase (Merriam 2002). This is so the data can potentially influence subsequent data collection activities (Gall *et al.* 2007). An iterative qualitative design is

often used when existing theory does not explain a phenomenon. In doing this, a researcher can gather data to build concepts, theories and hypothesis. The theory is built up from time in the field and is developed from initial themes, categories and concepts (Merriam 2002).

5.3.2 Qualitative Interventions

The project takes the form of a qualitative intervention in which physics video hooks will be integrated into the authentic context of the classroom. The intervention takes place in the classroom in order to be as naturalistic and as close to real life as possible. Hence, this is an examination of people in situ (Gall *et al.* 2007). The intervention approach is being used as the research wants to identify successful or unsuccessful components (Spencer and Britain 2003) of the hook videos and associated teaching methods. However, many factors can determine effectiveness as interventions are multifaceted with several components working in synergy (Hutchinson 1999). Defining true effectiveness under the variables of context, agents and costs is a demanding task. Identifying effective interventions requires long term assessment with a range of methodologies that are effective in the field and multiple settings (Penuel and Fishman 2012). This research is a feasibility test of physics video hooks within multiple classroom, school and community contexts.

5.3.3 Criticism of Qualitative Approaches

Qualitative methods are often labelled as being unscientific and anti-numbers (Sandelowski 2001), especially when critics who would label scientific knowledge as the “highest form of knowing” (Mays and Pope 1995, p. 109). It is argued that qualitative data is a collection of personal impressions subject to bias. They are wholly un-replicable and lack generalisability. Perceptions of humans may be wrong and some may be falsely conscious of realities that do not exist (Cohen *et al.* 2011).

However, socially constructed realities are at the vanguard of qualitative inquiry. There is a value laden component to naturalistic inquiry that is subject to criticism. This is most commonly manifested as criticisms of bias (Ryan *et al.* 2007). This is due to qualitative research following the principle of interpretive paradigms (Devetak *et al.* 2010). The focus of any study is the subjective realities developed by individuals through their direct or indirect experience of events. Their active cognition of circumstances is integrated into their specific context and this is the crux of what the researcher is attempting to understand. The research participant’s message is conveyed through the form of words, visual cues with a specific syntax, hidden meanings, breaks in speech and body language that a researcher must perceive and interpret (Devetak *et al.* 2010). Within such

a context, a researcher must be aware of his/her impact on phenomena being studied and how they will influence discursive reality (Devetak *et al.* 2010). This is because the researcher plays a central role in qualitative studies (Malterud 2001). Depending on their philosophy, their viewpoint is limited and determines what theory can be drawn out from data. This creates a schism between researcher observations and actual events. This human element of naturalistic research styles is present in both the researcher and research participants (Creswell and Miller 2000). Adequate accounts of the implications, inherent human error and bias should form an account that is integral to the study. All researchers have the potential to arrive at different conclusions, albeit equally valid (Malterud 2001). The primary researcher is often noted as a ‘research instrument’ for data collection and analysis (Creswell and Miller 2000, Merriam 2002). A human instrument is adaptive and responsive both in the immediate and long term. However, the major shortcoming is the inherent bias in this process. Rather than trying to eliminate bias, the qualitative researcher identifies partiality from the start of the project (Merriam 2002).

The crux of the argument is that qualitative and quantitative data are fundamentally different when ensuring validity and reliability. Indeed, reliability is the foundation of quantitative research within the positivistic tradition. However, all research involves the collection of evidence and various collection methods have their inherent strengths and weaknesses (Mays and Pope 1995). Hence, they need to be applied correctly in appropriate scenarios.

5.3.4 Establishing Rigour and Validity in Qualitative Research

One of the contemporary dialogues in qualitative research is establishing rigour throughout research (Whittemore *et al.* 2001). Philosophical debate between postmodernism, relativism, critical realism and pluralism open a variety of stances for the novice researcher to adopt (Whittemore *et al.* 2001). Extreme relativists would posit that all research perspectives are unique and valid in their own realm. Although this implies that research cannot derive insights applicable to action. The antirealist position argues that qualitative research is separate and distinctive from other forms of research and should not be judged by the same criteria. There are no hard and fast solutions to assessing quality in qualitative research, yet, there are some broad headings (Mays and Pope 2000).

The nature of unification in qualitative data relies upon incremental efforts made during the research process to ensure reliability mechanisms are woven into every step of the research process (Morse *et al.* 2002). This is vital in the current study as it is conducted by both the designer

and researcher. Hence, the positionality of the researcher and the lens under which the study is examined, an important factor in any thesis, can be susceptible to predispositions or bias (Whittlemore *et al.* 2001, Malterud 2011, Mays and Pope 2000). Cognisant of this, the concepts of validity and rigour must be established throughout all stages of work. The process of embedding rigour and validity into the research processes will be explored presently.

5.2.4.1 Rigour

The rigour of a study may be measured by the degree to which the researcher is transparent about the design and role in the research process. Rigour impacts all stages of research and can be applied to broad stages such as documentation, procedures and ethics (Ryan *et al.* 2007). To demonstrate rigour in research, audit trails, peer reviews, deviant case analysis and coding checks are all utilised (Gibbert *et al.* 2008, Morse *et al.* 2002). Evidence of a decision trail at each stage of research provides confirmation for readers that theoretical and methodical issues were negotiated correctly (Ryan *et al.* 2007). From the first step to the last, qualitative research must be transparent and coherent so that another researcher can examine data and determine that findings are plausible (Mays and Pope 2000, Spencer and Britain 2003). Establishing transparency creates a high level of reliability within a project. “Reliability refers to the stability of findings” (Whittemore *et al.* 2001, p. 523). It denotes the absence of random variables, enabling researchers to arrive at accurate results. It should be obvious to an outsider that the insights of a researcher would be achieved by another researcher using the same methodological processes.

5.3.4.2 Validity

Barab and Squire (2004, p. 10) argue that “if a researcher is intimately involved in the conceptualisation, design, development, implementation, and re-searching of a pedagogical approach, then ensuring that researchers can make credible and trustworthy assertions is a challenge”. The quandary resides in the fact that a researcher brings their own lens to a study. This is especially true in qualitative studies in which the researcher acts as the research instrument. In determining validity, different perspectives from different people set out how accurate a study is and whether it is free from bias (Creswell and Miller 2000, Onwuegbuzie and Leech 2007). Bias mainly arises from the fact that qualitative study is not built on facts or figures, rather an analysis of theories that are generated during the examination course (Klieger *et al.* 2010). Investigator bias can be a point of concern due to pre-acquired opinions or a desire for a certain set of results (Klieger

et al. 2010, Sofaer 2002). Hence, reinforcing validity throughout a project is a keystone of research practice. Validity criteria in qualitative research include plausibility, relevance, completeness and confirm-ability. These criteria apply to descriptive, interpretive and theoretical projects. They are used as judging standards; however, techniques are needed to achieve validity. Thoroughness, vividness, explicitness and congruence in descriptive writing and analysis are all techniques to ensure validity (Whittemore *et al.* 2001). Validity can be sub divided into internal and external validity. Internal validity asks whether the study investigated what it set out to, external validity asks, in what contexts findings can be applied (Malterud 2001).

According to Merriam (1995, p. 53) internal validity relates to “how congruent are one’s findings with reality?” Internal validity refers to the impact of spurious effects to which the researcher fails to negotiate. This is of particular concern in exploratory research whereby the research attempts to ascertain the event x led to y (Yin 2014). Any assessment of qualitative studies must ask if the researcher provides a plausible argument for findings based on logic and evidence. It should also show how such a result could not be caused by another unauthentic factor (Gibbert *et al.* 2008). If this relationship is incorrectly identified, it means the research design failed to fully incorporate all aspects of the study, resulting in poor internal validity.

Reality within the qualitative paradigm is constructed and ever-changing. A researcher working in an educational setting, offers his/her interpretation of someone else’s reality (Merriam 1995). Whenever a researcher makes an inference, there is a threat to internal validity as an inference based upon data may not be correct (Yin 2014). However, one of the strategies employed within this research to bolster internal validity was ‘member checking’ (Merriam 1995). Based on recommendations by Merriam (1995) and Lather (1986), observation reports and interview transcripts were sent back to teacher participants for review. They were asked if they approved of the data and if they would like to amend any of their input. This is what Lather (1986) refers to as ‘face validity’. It adds credibility to the data by recycling the data back to participants and triangulating the researcher’s interpretations of events (Merriam 1995). Therefore, interpretations are not wholly derived from one source, adding credible weight to findings.

“In qualitative inquiry, the aim with respect to external validity is to ascertain whether the study hypothesis or results can be applied to other settings” (Malterud 2001, p. 485). Contextual background material, such as demographics and study sites are fundamental so the reader can ascertain validity for particular situations (Bakker and van Eerde 2015). Findings are not supposed

to be applicable to the population at large (Malterud 2001). However, external validity (Merriam 1995), also referred to as generalisability (Gibbert *et al.* 2008) or trustworthiness (Graneheim and Lundman 2004) states that an account of phenomena in one situation should be applicable to another. Yet, qualitative studies do not allow for statistical inferences. This, however, does not mean that qualitative studies are devoid of external validity (Gibbert *et al.* 2008). No findings will be universally transferable, but a study design should demonstrate an adequate level and consideration of external validity (Malterud 2001).

In terms of external validity, Graneheim and Lundman (2004) discuss its three core facets of credibility, dependability and transferability. Credibility focuses on the process of attaining data and how the process of analysis matches the intended focus of the study. Selection of content, participants and methods all impact on the credibility. Credibility in terms of results deals with how codes and categories represent the data and instances in which they (intentionally or unintentionally) exclude data (Graneheim and Lundman 2004). Subsequently, dependability refers to the various altercations and changes a researcher makes to design and analysis in a project to determine instability. When data is too extensive and the collection period is over a long period of time, the chances of inconsistency in the research approach are augmented (Graneheim and Lundman 2004). However, the collection of data over a longitudinal time period aids in the process of submersion and helps the researcher gain an in-depth understanding of phenomena (Merriam 1995). Therefore, the reflection and reflexive practices instigated in this research will be key pertaining to the dependability of the data. Finally, transferability describes how research findings can be transferred to other groups or settings. This can be facilitated by giving clear and concise descriptions of participants and context (Graneheim and Lundman 2004). Credibility, dependability and transferability are key facets to this research project and methodology. These methods and other methods to ensure rigour and validity have been embedded throughout this research and writings.

5.3.5 Qualitative Methodological Strategy

Having established and defended that the methodology will take a qualitative stance, the question remains as to what methodological paradigm is most suitable. The method chosen must consider that the research has created and is advancing a designed artefact in the Physics Video Hooks. Liu *et al.* (2009) talks to the need for research in areas to support active and adequate use of educational technology in the classroom. The integration of technology into complex educational environment

leads to a myriad of changes within that setting. Similar to a ‘domino effect’, the complex real world context, already in flux, undergoes repeated alterations (Amiel and Reeves 2008). Educational technologies exist in the interplay between knowledge, subject content and pedagogy (Mishra *et al.* 2009). Hence, a methodology is warranted that is adaptable within a fluctuating real world context. The method requires a flexibility and responsiveness to design that will aid in the development of a practical and theoretical impact both in the locale and beyond.

5.3.6 Qualitative Methodological Selection and Rationale

In attempting to address the multicomponent and nascent focus of this research, to develop a type of educational technology that acts as an effective hook both for secondary science teachers and their respective students, an approach is warranted to analyse issues, allocate solutions and implement processes in answering the research questions.

In making a methodological decision, the researcher was fully aware of the ‘credibility gap’ within educational research (McKenney and Reeves 2013). According to Wang and Hannafin (2005), educational research continually fails to influence practice. Kaufman (2003) address the schism between the theoretical groundings in education and the actualities of practice. The gap between academics and practitioners has led to the perception that theory is not relevant in the classroom (Dede 2005). This issue is further accentuated when examining the area of technology and pedagogy. Evidence suggests that the full potential of technology is not being realised in formal educational settings (Bocconi *et al.* 2013). This is reiterated by Amiel and Reeves (2008) who state that education has changed less due to technology than any other facet of society. So, why is this the case? There is a plethora of regularly cited justifications for this, however, a lack of practical theories for educators to adopt is one of the largest concerns. Often, educational technological innovations are developed with incorrect or contradictory theoretical foundations (Wang and Hannafin 2005). This is, in part, due to the utilisation of unsuitable research methods within educational inquiry. Traditional research methods maintain the norm in which theory is rarely challenged and when it is, its adoption into the classroom, is stagnant. As noted earlier, classroom environments are too complex to accommodate single test or ‘one-shot’ research methods. Such designs are too general for any valid conclusions to be drawn (Wang and Hannafin 2005). Thus, the decision pertaining to methodology was made in light of the research requiring a holistic impact on general practice and theory. A methodology was required that would strike a balance in terms of its classroom impact and research output. Under the qualitative umbrella, case

study, action research and Design-Based Research (DBR) methodological approaches were considered. Such approaches can be utilised to identify effective interventions through longitudinal assessment with a range of methodologies through testing in the field with multiple settings (Penuel and Fishman 2012). These methodological paradigms were initially examined as they could be grounded in the context of the classroom, while also displaying theoretical validity and reliability. Their decision making process will be explored currently.

A case study can be defined as “a research method that facilitates a deep investigation of a real life contemporary phenomenon in its natural context” (Wahyuni 2012, p. 72). Case studies are designed to portray and analyse real individuals and situations through accessible accounts (Petty *et al.* 2012b). They can take the form of action or intervention as in this research and give a sense of grounded reality (Cohen *et al.* 2011). In this way, case studies with an intervention based approach set in a naturalistic context are similar to design-based approaches. With this, came about a dilemmatic methodological juxtaposition between the paradigms. Contrasting the two, case studies differ from design-based methods as they lack a focus on iterative design and cyclical changes based upon context. Case studies or multiple case studies are more akin to a ‘one-shot’ research framework. That is, a case study paradigm would restrict adoptable and adaptable design changes to the hook technology or pedagogy. What is implemented in the pilot and main research phase remains static and could prove to be restrictive in the ever changing and complex classrooms being studied. Both approaches can be characterised as interventionalist. However, design-based intervention approaches manipulate a naturalistic setting by varying a condition per theory and findings. This type of positive modification becomes more powerful with multiple consecutive iterations which is necessary if the condition under scrutiny does not already exist in the environment (Bakker and van Eerde 2015). Physics video hooks represent a completely new design artefact within educational settings. Iterative change is an important aspect to forwarding the hook design in tandem with an ever-changing real world context. Hence, due to the incremental avenues of research design research methods could provide, along with a fluid approach to research that matches the movement of the setting under scrutiny, DBR was favoured over case study approaches. However, action research can also be utilised as an intervention approach that allows for iterative and reflective changes within context and had to be considered as a potential methodology.

Chapter 5: Methodology

DBR is often compared with action research, however, there are some distinct differences between the two approaches. Action research is employed when practitioners study their own learning situation (Cohen *et al.* 2011). With action research, the researcher must be a participant and the focus is on action and improvement of a research focus that emanated from a learning situation. This entails evaluative, reflective and some design aspects with regard to the setting (Bakker and van Eerde 2015). Conversely, DBR is unlike evaluative type research as it regards a successful intervention as the interplay between the intervention and the context. Its goal is to refine predictive and generative theories of learning rather than perfecting or understanding a personal or local practice (Design-Based Research Collective 2003). The focus is on creating and refining both practical and theoretical constructs. This core facet of design is what sets DBR apart from experimentation and evaluative research (Barab 2006). This research requires a methodology that directly accommodates design as the inception of the project is based around an ADDIE instructional model. The design of a new learning environment is a crucial aspect of the research (Bakker and van Eerde 2015). Therefore, action research cannot be utilised as a suitable method. At this juncture, DBR is selected as the methodological paradigm with an overarching qualitative scheme due to its ability to holistically and continually revise a new piece of educational technology with a distinct focus on theory, practicality and design.

As a methodology, DBR can appease previous concerns by potentially bridging the gap between theory and practice in technology driven educational environments. DBR is an iterative process that systematically attempts to refine innovations while also creating design principles that can guide other research (Amiel and Reeves 2008). The researcher defends this choice and highlights its validity through the literature as DBR creates a symbiotic conduit between pedagogy and educational technology (Amiel and Reeves 2008, Dede *et al.* 2004, Edelson *et al.* 1999, Hakkarainen 2009, Long and Hall 2015, Wang and Hannafin 2005) rendering it highly suitable for this project. DBR approaches represent the most fruitful methodological avenue for real gains that tangibly benefit all stakeholders in educational environs (Reeves *et al.* 2005). It allows for evidenced based findings that are more scientifically sound than traditional educational research (Sandoval and Bell 2004). However, DBR is a complex methodology entailing numerous interwoven iterative cycles. The following provides a more detailed overview of DBR methods and further justification behind the choice of this methodology.

5.4 Design-Based Research

5.4.1 Origins of Design-Based Research

Although the origins of DBR were developed by Brown (1992) and Collins (1992), pedagogical design strategies have married theory and practice for over a century. The ideology of having a design approach to behavioural science is not new with Hugo Münsterberg (1899) and John Dewey (1901) both discussing approaches that would link theory to practice. Such discussions have evolved over the last century, although, the quest for understanding, for better or worse, has been shaped by the empirical cycle of scientific endeavours as bringing empirical research into complex and naturalistic settings is a difficult quandary. The educational sciences have spearheaded efforts to create a type of research methodology that would resolve the aforementioned problem. The desire stems from the need for relevant and useful knowledge that is readily applied to real world circumstances (McKenney and Visscher-Voerman 2013). This issue is highly exacerbated when it comes to educational research as noted by the infamous ‘credibility gap’. This is a phenomenon in education whereby research with its inherent positivistic lens has had little impact on the “swampy lowlands” (Schön 1983, p. 42) of teaching and learning (Design-Based Research Collective 2003).

In bridging the ‘credibility gap’, a developed and mature approach to scientifically rigorous investigations into real world contexts has emerged in the last two decades. Design-Based Research (DBR), also termed ‘design research’ (Bereiter 2002, Collins *et al.* 2004), ‘educational design research’ (Van den Akker *et al.* 2006, Bakker and van Eerde 2015) and ‘design science’ (Alghamdi and Li 2013) was initially actualised by Brown (1992) and Collins (1992) as design experiments. The methodology arose from the dissatisfaction with existing methodological paradigms for exploring real world classroom interventions (O'Donnell 2004). At the time when DBR was developed, empirical classroom research took place in laboratory settings. A schism was noted by Brown (1992) who believed that positivistic influences were dominating and restricting research into naturalistic socially constructed environments. Scientific, laboratory based studies are socially isolated with the testing of strict hypotheses. In contrast, an approach to research was warranted that operated in messy contexts with multiple variables requiring identification and characterisation along with profiling of their interplay (O'Donnell 2004). At the same time, Collins (1992) put forward the idea that educational research should be akin to a ‘design science’ in which systematic experimental variants should determine effectiveness (Sandoval and Bell 2004). Brown (1992) refers to design experiments as engineering a working environment. According to

McKenney and Vissher-VoerMan (2013, p. 3), “Design research is a genre of research in which the iterative development of educational products provides the setting for scientific inquiry.” Therefore, DBR is set apart as a method of iterative experimentation that embraces the uncontrollable variables of the real world. This is the rationale behind DBR being advocated as an approach to fill a niche that was widely deemed to be missing from the educational methodological spectrum.

5.4.2 DBR: An Introduction

“The design-based researcher is humble in approaching research by recognizing the complexity of interactions that occur in real-world environments and the contextual limitations of proposed designs” (Amiel and Reeves 2008, p.35).

Design-Based Research (DBR), within the last 20 years has received considerable attention as an emergent methodological framework that can guide better and more relevant research results in the areas of education (Amiel and Reeves 2008, McKenney and Visscher-Voerman 2013) and technological innovation (McKenney and Reeves 2013). DBR combines basic research, which is concerned with understanding and generating knowledge, while also embracing applied research that is aimed at creating solutions to problems. It is a blend of empirical educational research and theory-driven design. It examines the how, when and why of educational innovations in a real-world context (Design-Based Research Collective 2003). Hence, as a research paradigm, it is adept at assessing innovative technological environments (McKenney and Reeves 2013). It is claimed to have the potential to close the gap between theory and practice and develop frameworks that are designed to support learning (Bakker and van Eerde 2015). DBR addresses such claims by examining interventions from a holistic approach and enacting experimental interventions. Cycles of interventions are enabled through interactions between students, teachers, environments and materials (Design-Based Research Collective 2003). The materials in question represent the design feature implemented into a learning ecology and may include educational tools, products, curricula or teaching or learning activities (Bakker and van Eerde 2015). The goal of DBR is dual advancement of the artefact from both practical and theoretical orientations so that it is contextually transcendent (Kelly 2004).

The engineered artefact is then systematically examined within its desired context (Barab and Squire 2004, Brown 1992). Bakker and van Eerde (2015) describe this process as didactical engineering as a product may have to be designed with whatever resources and theories available

to create a hybrid, primitive product that fills an educational niche. Products of DBR are then fine-tuned through the development of domain specific solutions to quandaries through the study of environs that purport them (Cobb *et al.* 2003). Theoretical and practical derivatives are judged on usefulness and innovativeness. Fine tuning comes about through cyclical intervention and experimentation. This involves the development, testing and refinement of an intervention in a continuous cycle of improvement (Hakkarainen 2009). Figure 5.1 displays the vital continual process of refinement within the DBR process with a focus on design principles.

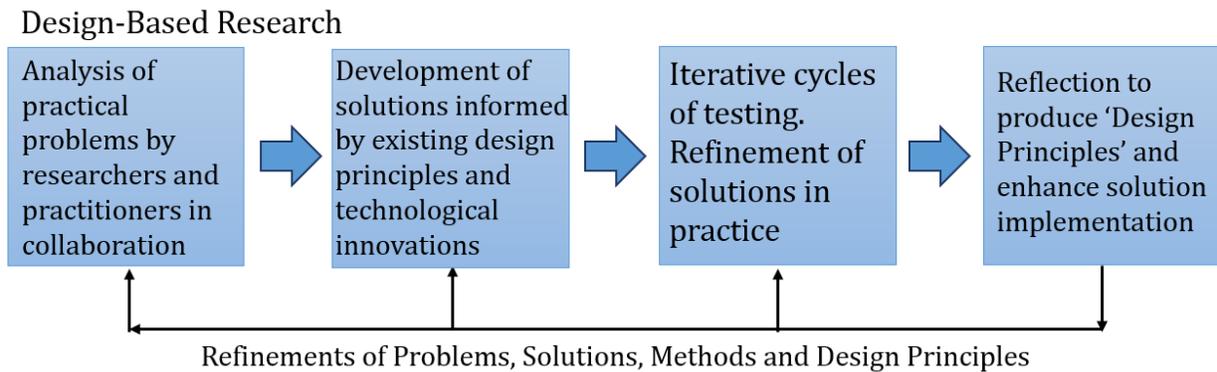


Figure 5.1: Iterative process of DBR with a focus on design and theory in authentic contexts (Adapted from Reeves (2006))

Systematic revisions involve the addition and subtraction of various design elements based on evidence derived from the context and relating it back to theory. Thus, the experimentation is what allows researchers to test, generate and forward theory (Barab and Squire 2004). In this way, DBR goes beyond an evaluation of a designed artefact in that any intervention must be grounded in theoretical claims with successful interventions in DBR being considered a joint product of design, intervention and context (Design-Based Research Collective 2003).

With such an output, typical of DBR are explanatory and advisory aims. In this way, theoretical insights into teaching and learning can be generated. The typical example being: “under conditions X, using educational approach Y, students are likely to learn Z.” (Bakker and van Eerde 2015, p. 4). This is a simplified model of DBR as it is a multi-layered approach with several research stages. For example, a project may examine how to teach ecology, however, the research might take into account current teaching practices or student motivations. Along with this, a research environment has to be designed and then evaluated. Hence, DBR contains review,

evaluative, comparative and descriptive stages (Bakker and van Eerde 2015). The various stages and defining characteristics of DBR will be explored in the following sections.

5.4.2.1 Simultaneous Advancement of Theory and Design

DBR aims to solve significant problems facing educational practice, but also pursues new knowledge that can inform such practice. In this way, DBR as a research methodology is dual purpose (Dede 2005). The design of learning environments and theory are intertwined (Bakker and van Eerde 2015, Design-Based Research Collective 2003). As such, DBR is a means of supporting learning while accompanying the limitations of design artefacts and domain specific norms (Cobb *et al.* 2003). Pertaining to theory development, a researcher through their iterations must move beyond theory implementation into theory development with evidenced based claims. In general, this results in the creation of a domain theory that resides in similar contexts and is wholly generalisable. A domain theory embeds a problem in terms of local teaching and learning and should be a welcome advancement of knowledge in a particular field (Alghamdi and Li 2013). As Hakkarainen (2009, p. 97), states, DBR “strives toward both the development of an intervention to address a problem in practice and empirical investigation yielding theoretical understanding that can inform the work of others”. Hence, in yielding both theoretical insights and design principles, DBR can address a problem in practice (Hoadley 2004). Designs within DBR are specific in their goals (Wang and Hannafin 2005) and although design experiments may take place in a limited number of settings, theory generated is not intended to totally reside within that sphere (Anderson and Shattuck 2012). The theory must examine broader phenomena and be more generally applicable to educational practice (Cobb *et al.* 2003). Combined, the input and output should contribute to learning theory and be practical for the purposes of dissemination (Brown 1992). Therefore, theory generated must be of practical use. This will be explored in the following section.

5.4.2.2 Theory that ‘Works’

Research from designs must lead to practical theories of relevance for educational practitioners and designers (Design-Based Research Collective 2003, DiSessa and Cobb 2004). DBR should endeavour to construct theory that is aligned with practitioner’s pragmatic requirements in their context (Reeves *et al.* 2005, Wang and Hannafin 2005). Cobb *et al.* (2003, p. 10) posits that theories generated are domain specific and “must do real work”. This adage was first put forward by Dewey (1938) who posited that systems of inquiry should not be judged by their claims of

truthfulness, but by their ability to do ‘real work’. Cobb *et al.* (2003) continues to discuss grand theories of education such as constructivism that are important, but provide little guidance on creating instructional environments. New theory must inform prospective design and delineate such design in an exact fashion (Cobb *et al.* 2003). Theory generated from DBR should be practical, more notably described as ‘humble’ by Bakker and van Eerde (2015). What the author means is that theory generated or refined, connects to a specific domain. Domain theories represent a tapestry that describes the fabric of a teaching and learning situation and all of its interactions (Cobb *et al.* 2003, Edelson 2002). Such theoretical products can be prescriptive, predictive or normative (McKenney and Reeves 2013). However, it is postulated that theory must be still generalisable to other learning environments with a good level of transferability (Bakker and van Eerde 2015). Hence, constructs, must transcend the environments from which they were created and be applicable in other settings (Barab and Squire 2004).

5.4.2.3 Cyclical Interventions

DBR engineers a learning space with the intent of creating new theories, practices and artefacts (Barab and Squire 2004). Such engineering is subject to cycles of experimentation and revision. Through this process, DBR develops new innovations rather than simply optimising what works (Cobb *et al.* 2003). A DBR research project can be compared Formula 1 team that develops their own cars, inventions and innovations to better their chances of success. It is not the ‘kit car’ or ‘rally’ team that simply purchases a car and optimises the components. One team has innovated and pushed forward the boundary of technological gains. Per contra, the other team has not developed anything new, rather they have utilised what already exists.

To achieve innovation through design, multiple rounds of testing and development are required. Such prototyping is an iterative refinement as interventions in educational institutions are rarely perfect (Anderson and Shattuck 2012). This interventionist research approach takes place in a cyclical manner. Cycles take the form of enactment, analysis and redesign (Design-Based Research Collective 2003, Shavelson *et al.* 2003). It is a process orientated approach. It is often labelled as experimentation in real-life settings (Shavelson *et al.* 2003). Cobb *et al.* (2003) notes that this cyclical strategy must put theory in harm’s way. This means that every cycle tests and experiments with theory and the results may not turn out as planned. Thus, every cycle has a prospective and reflective part to analysis. The prospective part refers to what the design is intended to achieve with a hypothesised learning process in a context. This is often grounded in

theory. On the reflective side, the researcher must examine intervention results from a number of perspectives but also create reflections after every phase. Reflection allows for the modification of theory dependent upon characteristics realised in the classroom (Cobb *et al.* 2003). Bakker and van Eerde (2015) consolidates this point and state that interventions should be steered by reflections. The researcher must amalgamate what was theoretically hypothesised along with what occurred in reality (Barab and Squire 2004). This process can lead to positive design changes in the following phase. Combined, the prospective and reflective tell the story of an enacted cycle (Cobb *et al.* 2003).

5.4.2.4 Authentic Contexts

DBR is accomplished at the ‘chalk face’ of education. What this means is that every intervention cycle must demarcate successes and failures while refining the understanding of design, theory and practice under the influence of complex and often messy environments (Design-Based Research Collective 2003, Dede 2005, Wang and Hannafin 2005). Central to the DBR process is this ‘messiness’ of real world practice with the naturalistic context that plays a key cast member in the research (Barab and Squire 2004). Pertaining to classrooms, they are the socially constructed environments that occur every day and are unlike laboratory settings and other ‘artificial’ environments (Brown 1992). Therefore, DBR captures social interactions (Barab and Squire 2004) context, personal histories, psychology and unexpected events (Hoadley 2004). With such a holistic and contextual approach (Design-Based Research Collective 2003), DBR results in a greater understanding of the myriad of patterns within a complex learning ecology (Wang and Hannafin 2005). A learning situation is an interactive system of multiple factors which the DBR methodology recognises as a hallmark of educational settings (Cobb *et al.* 2003, Liu *et al.* 2009).

With its focus on authentic environments, DBR is seen as having a higher chance of impacting on education over other methodologies (Barab and Squire 2004, Anderson and Shattuck 2012). However, operating in authentic contexts entails working with the agents that reside, work and learn within said context (Alghamdi and Li 2013). DBR operates within communities of practice and innovates as a response to evidence with the goal of scientifically rigorous improvement (Bereiter 2002, Barab and Squire 2004). Within educational research, this entails collaboration with teachers. As the previous section noted, design takes place through interventions that are enacted by teacher participants (Cobb *et al.* 2003, Liu *et al.* 2009). Herrington *et al.* (2007) notes that DBR requires intensive and long term collaboration between researchers

and practitioners. With this longitudinal aspect, teacher participants are co-constructors of the design and are a keystone through which enactment of successful interventions takes place (Wang and Hannafin 2005). This allows for the development of meaningful results that impact practice in the local context. This aids in scrutinising random results, relationships and reinterpretations in an effort to define the essence of the innovation based intervention (Design-Based Research Collective 2003).

5.4.2.5 Data Collection Methods

DBR is not defined by methodology (Bereiter 2002). DBR does not have a set data collection, analysis and presentation method (Wang and Hannafin 2005, Yamagata-Lynch 2007). The development of research throughout cycles is dependent on methodologies that can illuminate outcomes of interest (Design-Based Research Collective 2003, McKenney and Visscher-Voerman 2013) and research questions (Bakker and van Eerde 2015). DBR can utilise any data collection or analysis methods, however, it is the goals of DBR sets it apart from other research genres. It blends the goals of empirical and applied sciences (McKenney and Reeves 2013). In this way, data collection methods can be open or closed. DBR expands on a typical experimental model since it examines the why and how of what works. It does not just simply point to what works (Bakker and van Eerde 2015). Methods are implemented systematically and purposefully. Hence, multiple methods are applicable in DBR including observations, interviews and surveys. However, methods must be implemented systematically and purposefully (Wang and Hannafin 2005). In terms of data accumulation Brown (1992) warns of acquiring too much data within an intervention. The author postulates that too much data may slow the progress of positive changes and lead to a smaller contribution to educational knowledge (Brown 1992). This reaffirms the notion that methodology in a DBR project must be purposeful to illuminate areas of interest.

5.4.2.6 Continual Refinement

DBR forwards theory and design from bad to good and good to excellent and beyond. It is defined by small continual improvements (Kelly *et al.* 2008). This is actualised through proximal and distal perspectives. Proximal design is informed by an internally focused creation of a product, while the distal perspective modifies design from an external orientation through intervention. Both perspectives should be aligned and continually feed into one another (Bakker and van Eerde 2015, McKenney and Visscher-Voerman 2013). In achieving such refinement, Wang and Hannafin

Chapter 5: Methodology

(2005) state that data must be analysed immediately and continuously. Analysis is simultaneous with collection and coding to improve the design. Analysis requires systematic documentation so that the development process, judgements and procedures can be openly assessed (Edelson 2002, Alghamdi and Li 2013). DBR and the journey from design inception through proto-refinements is a continual work in progress (Kelly *et al.* 2008). With such a milieu of decisions within iterations, the movement of design and theory from A to Z should be logical and thorough. As Edelson (2002) notes; certain elements of design are implicit, however, they must be made explicit within research.

The previous writing has outlined the various characteristics that define the DBR process. These sections are summarised in table 5.1 below.

Table 5.1: Displays the defining characteristics of DBR along with a descriptor and relevant authors

Defining Characteristic	Authors	Description
1. Simultaneous advancement of theory and design	Alghamdi and Li (2013), Bakker and van Eerde (2015), Cobb <i>et al.</i> (2003), Dede (2005), Design-Based Research Collective (2003), Hoadley (2004)	1. The design of learning systems and the development of proto-theories are intertwined and advanced in concert.
2. Theories derived must be useful and practical	Barab and Squire (2004), DiSessa and Cobb (2004), Edelson (2002), McKenney and Reeves (2013), Reeves <i>et al.</i> (2005)	2. DBR is pragmatic in how it gives practical guidance to instructors grounded in theory. Guidance must be transferable as theories developed must be sharable among practitioners.
3. DBR takes place in cyclical interventions	Anderson and Shattuck (2012), Barab and Squire (2004), Cobb <i>et al.</i> (2003), Shavelson <i>et al.</i> (2003),	3. Development and design is conducted through continuous cycles of design, analysis and redesign.
4. DBR works in authentic contexts with stakeholders.	Alghamdi and Li (2013), Barab and Squire (2004), Dede (2005), Herrington <i>et al.</i> (2007), Hoadley (2004)	4. Interventions take place in naturalistic contexts. DBR requires intensive collaboration with practitioners and stakeholders in the authentic setting to inform all aspects of design and theory.
5. Any data collection methods can be implemented	Bereiter (2002), McKenney and Visscher-Voerman (2013), Wang and Hannafin (2005), Yamagata-Lynch (2007)	5. The development of research accounts is dependent upon methods that can effectively and efficiently document the content and outcomes of the setting.
6. Process of continual refinement	Bakker and van Eerde (2015), Edelson (2002), Kelly <i>et al.</i> (2008), Wang and Hannafin (2005)	6. DBR requires a long incubation period in which implementation, reflection and iteration are key. It provides for innovation and reflection over time.

5.4.3 Criticisms of Design-Based Research

DBR has received its share of criticism since its inception. Of that criticism, one of the most noted arguments against DBR is that the complexity and messiness of naturalistic contexts, which do not lend themselves to experimental control, are too varied and entropic to accurately assess (Hoadley 2004). Thus, comparisons across design interventions can be flagged as an area for inaccuracy and potential error. However, in establishing rigor, it is argued that the only way to address this issue is through detailing and documenting all aspects of design decisions (Edelson 2002, Alghamdi and Li 2013). A comprehensive design history allows a research audience to negotiate the credibility and trustworthiness of a project. With the goal of establishing rigor and trustworthiness, the design history of this research along with all design decisions made is elucidated in the three analysis chapters.

Adding to the critique, Collins (1992) argues that design experiments sometimes are carried out by the designer of the intervention. Hence, they have a vested interest in making sure that it works. When designers embark upon research, many studies may lack a suitable theoretical grounding and therefore cannot refine and evolve theory (DiSessa and Cobb 2004). Part of this problem is that creative design skills and rigorous research generally do not overlap. Hence, the roles are performed by different people with divergent insights into the research context. The focus of DBR can be too much about the artefact or too much about theory without striking a balance (DiSessa and Cobb 2004). However, in combatting this, the researcher in this project is combining the role of designer and investigator. Yet, this raises the issue of bias which Hoadley (2004) notes as a key problem within DBR in that the researcher is the instrument through which all data is processed. As such, embedded with the methodology are strategies to ameliorate researcher bias. This is achieved through reflexivity and reflection in which researchers continuously self-assesses their subjectivity and personal role in the research. Further credibility is added to the study through establishing validity and rigor. For a deeper insight, reflexivity and validity are further explored in sections 5.11.1 and 5.3.4.2 of this chapter respectively.

The final criticism is that design experiments do not resemble that of a typical classroom, often due to the presence of a researcher in class and data collection tools that alter the naturalistic context (Mor and Winters 2007). Within this research, a clear and concise effort has made to reduce the unauthentic impact of both the researcher's presence and data collection methods to aid in augmenting the credibility of interventions. Barring the introduction of the hook to the classroom,

the context was often left completely unaltered. This was a strategy in design cycle 2 so that teachers could develop a pedagogy to use with the hooks, as they would any other resource. This would also enable the teachers to form opinions on the hooks and assess their students' reaction prior to the observation and interview that took place during and after the third hook intervention. Furthermore, the observation was a non-participant observation as opposed to a participatory observation. The researcher was a silent and stationary observer in the classroom. In addition, during the capstone phase, teachers were asked to utilise a short exit card survey designed by the researcher in the last five minutes of class. As a data collection method, exit cards are a type of assessment with which many students would be familiar as they are not an unusual occurrence in the classroom. In this fashion, the researcher attempted to maintain the natural setting by being as non-invasive as possible throughout all aspects of the research process. An overview of the three interventions, timings and data collection methods utilised is presented in section 5.4.4 below.

In combatting criticisms of the DBR approach, a researcher can seek to establish external validity throughout their design cycles. Transferability of theoretical derivations and design principles are central features of DBR and are imperative for establishing external validity. The validity of DBR often hinges on the changes that occurred in a given system. Even though the context of an intervention is messy and complex, a design researcher wants to create a loose level of replicability (Barab and Squire 2004). Replicability and transferability are the largest determinant of validity and reliability in DBR. Claiming success for an intervention is difficult unless it can be realised in other contexts (Design-Based Research Collective 2003). Findings are fluid within a context and design principles are readily transferable to relevant domains. Bakker and van Eerde (2015) asks, if an iteration is successful in one class, will it be successful in another classroom? However, this is not a completely strict procedure as the word 'loose' is used by Barab and Squire (2004) to operationalise the vast difference that may be present between contexts. Transferability does not have to be exact, but must be present. This is a hallmark of the DBR process.

5.4.4 Physics Video Hooks – Design Cycles

DBR cycles start with a design. In the case of this research, the design of the physics video hooks followed a modified ADDIE process to create the hooks in the form of a theoretical bricolage (Kelly *et al.* 2008). That is, a process that draws upon whatever theory and resources are available, to inform or revise models or artefacts that are relevant to research agendas (Bakker and van Eerde

2015). According to Wang and Hannafin (2005, p. 16), “Designers can adapt a mature theoretical framework or initiate a new one according to the purpose of the design and features of the setting”. For the purposes of the hook design a new theoretical framework had to be ‘cobbled’ (Edelson 2002) together from bits and pieces of relevant theory on A: the definition of a hook, B: the numerous digital video strategies that aid in hooking students and C: pedagogically, how the design should be implemented. This was done through an examination of all pertinent literature, albeit scarce, and indirect literature, which formed the majority of theoretical derivations extrapolated into the design (Wang and Hannafin 2005). The resulting framework is not final, rather, it is an initial guide or proto-theory.

At this point, a design must then be taken to the ‘test track’ of the classroom (Collins *et al.* 2004). Starting from the basis of theory and a designed artefact, a researcher begins with a hypothesis and various theoretical principles to examine how (O'Donnell 2004) the intervention process works (Edelson 2002). This is a cyclical process of intervention and revision so that the researcher can steer effective change (Design-Based Research Collective 2003). Multiple conjectures can be refuted and tested in the same phase and build toward the next cycle (Bakker and van Eerde 2015). Through addition, discarding and refinement the researcher gradually puts together a coherent model “that reflects their understanding of the design experience” (Edelson 2002, p. 106). What was originally disparate pieces, emerges as rounded scheme, not perfect due to the iterative nature of design, but seamless compared to the initial design (Edelson 2002).

However, a core attribute of DBR is that the enacted intervention may not go as planned (Hoadley 2004). Changes are made in DBR to create the optimum condition for the generation of the data corpus and within DBR “researchers continuously take their best bets” (Bakker and van Eerde 2015, p. 5). Yet, ‘mutations’ occur in cycles whereby the principles of design are undermined by enactment of the cycle in the learning context (Collins *et al.* 2004). Essentially, like experimentation, everything may not go as planned, however, using these results, the goal is continual improvement throughout all interventions.

The intervention strategy utilised in this research follows recommendations from Long and Hall (2015). The authors employed a three-stage iterative model encompassing a pilot (Design Cycle 1), mainstream (Design Cycle 2) and capstone phase (Design Cycle 3). The pilot intervention is a small scale exploratory study (Kortland and Klaassen 2010) that is used as a grounding for the mainstream phase. The mainstream phase expands on work of the former phase

by promoting successful and promising components of the research. Finally, the capstone phase is utilised as a verification process. Over the three cycles the goal is to create integrative and dynamic designs through research activities (Long and Hall 2015). Figure 5.2 demonstrates the development of theory and design through the three iterative research phases.

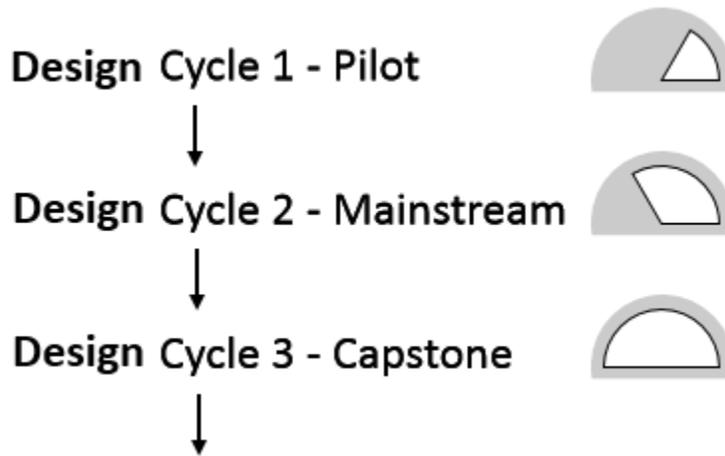


Figure 5.2: Iterative DBR cycles adapted from Long and Hall (2015)

Design cycle one, the pilot phase, took the form of a classroom based intervention and was deployed with a purposive sample of two pre-service science teachers to act as a proof of concept. The participants were asked to conduct one physics video hook intervention with a junior science class (11 – 15). Specific timings, directions and supporting documentation were provided with the stipulation that the hooks had to be used at the start of their respective lessons per theory (Lemov 2010). Semi-structured interviews were conducted with the participants upon completion of the intervention along with researcher observations of the class and reflections. This phase assessed both the hook design artefact in the naturalistic context of a junior science classroom, but also assessed the data collection tools as would be the norm in a traditional pilot. The pilot was exploratory and sought evidence to steer the research into the design cycle 2. This is the justification for the small number of participants as Bakker and van Eerde (2015) note that research and development within DBR can be more efficient with shorter cycles. This was the case as the pilot pushed forward pedagogical design principles for the next phase.

During the secondary design phase, ten secondary science teacher participants from across Ireland were recruited for the study using a purposive sampling frame (see Table 5.2). The

demographic varied from rural to urban schools. A mix of male and female teachers with diverse levels of experience were recruited. Teachers were asked to use three of the ten physics hook videos during three separate science classes inside a four-month period with a junior science classroom. A minimum of three videos per teacher is a representative sample from the suite of eleven as every video has the same design structure and framework. Hence, they are deemed comparable from a design perspective. Moreover, utilising more videos would be problematic for participants as the physics hooks are being implemented within science classes. As the science syllabus is divided as a triad, teachers spend one third of their time teaching physics and the rest of their time on biology and chemistry. Therefore, the window of opportunity in which to enact the intervention is limited and the current strategy embraces the naturalistic context of the science classroom. Finally, with a minimum of thirty interventions, it is postulated that any deviant videos or ones that do not align with the participant’s needs will be ‘rooted’ out of the current suite.

Table 5.2: Table of teacher participants along with school type, experience, subjects taught and the design cycles they enacted

Participant	School Type	Teaching Experience	Subjects Taught	Design Cycle
Darren	Co-Educational, Rural	< 1 year	Science/Physics	1
Jim	Co-Educational, Rural	< 1 year	Science/Physics	1
Aisling	Boys School, Rural	5 years	Science/Physics	2
Bill	Co-Educational, Rural	3 years	Science/Biology	2, 3
Catherine	Co-Educational, Urban	25 years	Science/Biology	2
Denise	Girls School, Urban	7 years	Science/Chemistry	2, 3
Emma	Co-Educational, Rural	10 years	Science/Chemistry	2
Eva	Co-Educational, Urban	7 years	Science/Physics	2, 3
Helen	Girls School, Urban	27 years	Science/Biology	2
James	Boys School, Rural	4 years	Science/Physics	2, 3
Richard	Co-Educational, Urban	7 years	Science/Chemistry	2
Yvette	Co-Education, Rural	6 years	Science/Physics	2

Teachers utilised the first two interventions to develop their own instructional strategies in a complete naturalistic context. Classroom observations were conducted by the primary researcher during the third hook intervention. Observations followed a systematic schedule refined during the pilot. Semi-structured interviews were conducted with teachers upon completion of the project. Researcher reflections were written after every interview and observation, lending further credence to the findings. Within this phase, teachers implemented three interventions each in their

classrooms. The mainstream phase was utilised to establish the interdependent design principles and theoretical framework within contextually transcendent settings. It fed into the final design cycle, the capstone phase (design cycle 3), which is utilised to verify and advance research findings.

Design cycle 3 worked with four of the teachers from the previous cohort in the mainstream phase. These participants were approached to continue with the research as they were the most successful at integrating the hooks into their teaching in terms of varied pedagogies and desired student impact. Furthermore, these teachers experimented with their instructional approach throughout the interventions to ascertain what worked best in their respective classes. Given this, they represent the most innovative teachers within the group who truly engaged with, and integrated the hook technology. Moreover, each phase of DBR sets out to ascertain what is a practical and feasible amount of data to acquire (Bakker and van Eerde 2015). Since design cycle 3 works more so with students, four teachers represent a large enough sample since this pertains to approximately sixty to eighty students. This decision was made with informed discussions with the researcher's Graduate Research Committee (GRC). As co-participants, the teachers developed specific timings and instructional guidelines for use as an accompaniment to the hooks in the previous phase. The most effective communal aspects of hook and instructional design were implemented during this phase. Teachers again were asked to conduct three physics hook interventions with the same class over a four-month period. Previous phases primarily worked with teachers, and students to a lesser degree. However, this phase worked more so with students over teachers. There were a number of reasons for this decision:

- Firstly, since DBR takes a holistic approach to context and stakeholders, student accounts were sought as important agents of the classroom.
- Secondly, as a research project that is attempting to integrate technology into the classroom, the initial phases worked with teacher participants before students. Teachers are the agents of change within their classrooms and if they do not approve of a new technology in terms of design and pedagogy (Bingimlas 2009, Szeto and Cheng 2014), then it will never reach the students. Once, the research had established that teachers were comfortable with and saw value in the hooks, then a student based phase could be implemented.

Chapter 5: Methodology

- Finally, working with students allowed verification of the previous phases findings and augments the credibility of the research.

Pertaining to methodology, throughout every physics hook intervention, every student was asked by their respective teacher to fill out an exit card survey. After the three interventions took place, the researcher conducted two semi-structured group interviews with student participants from each class, culminating in six group interviews in total with twenty-four students. Teachers were given a reflective template and asked to fill out a record of the interventions by detailing how and when the hook was used along with their perception of the student reaction. Researcher reflections were written after every group interview. The three phases are summarised in table 5.3 below. It is important to note that all phases assessed both teachers and students, however, the degree in which stakeholders were directly and indirectly assessed was modified based on the research needs within each intervention cycle (Bereiter 2002, Yamagata-Lynch 2007, McKenney and Visscher-Voerman 2013, Wang and Hannafin 2005). The data collection methods and tools noted in the intervention descriptions above will be fully realised in the following segments.

Table 5.3: Breakdown of design cycles, timeline and data collection methods

Design Cycle	Time Period/Duration	Participants/ Interventions	Data Collection Tools
Design Cycle 1: Pilot	2014 – October to December	Two pre-service science teachers Their respective students 1 intervention each, 2 total	Semi-Structured Interviews (2) Systematic Observations (2) Researcher Reflections/Journal
Design Cycle 2: Mainstream	2015 – January to April	Ten in-service science teachers Their respective students 3 interventions each, 30 total	Semi-Structured Interviews (10) Systematic Observations (10) Researcher Reflections/Journal
Design Cycle 3: Capstone	2016 – January to April	Four in-service science teachers (from previous cohort) Their respective students 3 interventions each, 11 total (one teacher could only enact two interventions)	Student Exit Cards (185) Student Group Interviews (6) Teacher Records (11) Researcher Reflections/Journal

5.4 Research methods

The three major sources of information in qualitative studies are from observations, interviews and document analysis. The specific strategy is determined by what method will yield the best information and answer research questions. Often there is a primary method complemented by another (Merriam 2002). Within this research, three design cycles are being conducted in which the communal aspect is that a video hook is being integrated into a junior science class. However, a multitude of methods are being employed across cycles to assess the interventions. The rationale behind this strategy is to answer the research question, but also to provide confirming and disconfirming evidence through triangulation.

5.5.1 Triangulation

Research in social situations must overcome bias, interpretation and impression. Good research needs assurance that what it observes and hears is true. The processes of gaining such assurance is called triangulation. Triangulation is a validity instrument where researchers seek confirmation

and congruence of multiple sources of information. It is a systematic process of discovering common themes to provide corroboratory evidence (Creswell and Miller 2000). It lends credence to internal validity by further verifying findings (Gibbert *et al.* 2008). Through ascertaining complementary data, one can determine common dimensions to the findings and increase their level of confidence in interpretations. However, results may also prove to be dissonant and require a rejection of previous assumptions (Farmer *et al.* 2006). Methodological triangulation involves the use of multiple research methods or data collection techniques (Merriam 1995). Interpretations need to be reinforced by other forms of data, which in turn will attribute higher levels of validity to a study (Stake 2013).

Interviews, observations, exit cards, group interviews, teacher journals and a reflective research journal are being used in this study as a form of triangulation. Qualitative data has always been accompanied by criticism, regarding validity and credibility. The main strategy to ensure validity and credibility through data collection is triangulation of data sources (Gall *et al.* 2007, Cohen *et al.* 2011, Devetak *et al.* 2010, Gibbert *et al.* 2008). Various methods can be employed and corroborated across a study to reveal consistent or contradictory findings. Similar patterns or convergence of data aid in developing an overall interpretation (Gibbert *et al.* 2008). It assumes that a weakness in one method will be compensated by strengths in another (Mays and Pope 2000, Creswell and Miller 2000, Mays and Pope 1995). In this study, the numerous research methods noted above will address issues of internal validity as many methods will be used to answer the research question. To further substantiate evidence and corroborate results, multiple respondents (teachers and students) are key to the data collection process. This forms part of the holistic nature of DBR, but also triangulates the data due to multiple types of participant (Bakker and van Eerde 2015, Farmer *et al.* 2006).

5.5.2 Pilot

The pilot within this study was a dual-purpose research event. The pilot phase tested both the DBR intervention in terms of design, context and theory, however, it was also utilised to pilot data collection methods. Therefore, both the research intervention and the layout of the methodology were subject to piloting during this phase. Pilot studies are a typical procedure for quality in envisioned studies (Cohen *et al.* 2011). It is a test of feasibility in which a trial version of events is implemented (Sampson 2004). This is preparation to ensure the smooth running of the main study. It can also give advance warning that the project may fail due to inappropriate overly

complicated instruments (Chenail 2011). The pilot consisted of implementing the methodology with two students from the NUI Galway Professional Masters of Education (PME) class of 2014. Both participants were pre-service teachers. It was decided to work with these teachers as a proxy for in-service teachers so as not to take from the potential pool of science teachers that would be recruited to the study. The pilot was implemented with one intervention taking place during the teacher's class. The researcher observed the intervention and conducted an interview after.

Piloting in qualitative studies is particularly important for the novice researcher developing their skills and interview technique (Van Teijlingen and Hundley 2002). The pilot was also used to refine research tools and allow the researcher a chance to gain experience with both observation and interview methods. People differ greatly in their ability to interview someone and draw out answers. Experienced interviewers know how to tease out knowledge. This is one of the motivations behind piloting as it allowed the novice researcher to become more proficient in interviewing techniques (Stake 2013). It also allows for the refinement of the semi-structured interview tools. This is pivotal as participants may misunderstand questions (Elton-Chalcraft *et al.* 2008). Piloting is pivotal for interviews in order to attain unbiased data. Additionally, some questions will be repetitive or redundant representing a waste of time for all parties involved. During the piloting process, a researcher can become aware of communication breakdown, where rephrasing or deletion of questions is needed (Gall *et al.* 2007).

Additionally, the pilot was used to practice and refine the observation schedule. It is noted by Bodgan and Biklen (2003) how the researcher's ability to take field notes increases with practice. The writing of field notes represents a researcher's particular style. They should be thorough and clear without an emphasis on grammar or spelling (Bodgan and Biklen 2003). For a fuller delineation of how field notes were taken, please see the field notes section under observation (5.7).

5.6 Interviews

The project will incorporate interviews with teachers to aid in answering the research questions. Interviews are among the most common data collection methods in qualitative research. There is a wide variation in interviewing approaches that have emerged from diverse disciplinary perspectives (Cohen *et al.* 2011). Good interviews rely on the researcher truly listening to what the participant says without the influence of biased perceptions. This is advised to maintain the

integrity of raw data. It is also recommended to tape record an interview as memory should not be relied upon. A daily log also advisable to avoid distortions in data (Savenye and Robinson 1996). Cohen *et al.* (2011) agrees and notes how interviews are prone to the subjectivity and bias on behalf of the researcher (Cohen *et al.* 2011). In light of this, all interviews will be tape recorded and transcribed.

Interviews are grouped loosely as unstructured, semi-structure and structured (Cohen *et al.* 2011). The latter is similar to a verbal survey and not as prominent in the qualitative tradition as the former two. No interview can be truly unstructured, however, interviews can become incrementally more or less structured depending on paradigms, research aims and questions (Savenye and Robinson 1996). This project will employ a semi-structured interview approach. Semi-structured interviews can form the entire data source for qualitative projects. They entail a set of pre-determined open-ended questions, with room for prompts and other questions depending on the schedule and unprecedented dialogue. They are the most widely used format and take between thirty minutes and several hours to complete (DiCicco-Bloom and Crabtree 2006). The following section will fully delineate the interview design and approach.

5.6.1 Design

When designing interview questions, a novice researcher must pay due care and attention as you only get answers to questions you ask (Elton-Chalcraft *et al.* 2008). The first step in designing an interview is setting out exactly what the research is trying to achieve. This is defined by the research questions and purpose of study (Gall *et al.* 2007, Cohen *et al.* 2011, Stake 2013). This is where Elton-Chalcraft *et al.* (2008) advises caution as research questions form the basis of interview questions, hence, if the research questions are poor, they will negatively impact the rest of the study. The design of an interview must adequately translate research questions into applicable ones. Similarly, the interview questions and schedule must suitably reflect what the research is attempting to discover. Question format, response mode and question ordering require consideration to ensure quality data. The phrasing of questions is influenced by the participant's level of education, the depth of information required, the subject matter and the extent to which the interviewer has an insight into the respondent's world. This will also influence whether questions are specific/open-ended or indirect (Cohen *et al.* 2011).

This is a qualitative, iterative and exploratory study, as such, interview questions are broad in their style. The approach adopted is less structured as the researcher is seeking out rich narrative

data. Flexibility will be a key focus of the interview as ancillary conditions may become central to the project. The project has 17 standardised open-ended questions some of which involve prompts or explanations. There are some fixed questions which include Yes/No responses and these are followed up with probing questions which seek the reasoning behind responses. This is akin to a semi structured approach. When compared with other interview techniques, this has the advantage with reduced bias and increased validity (Gall *et al.* 2007). As advised by DiCicco-Bloom and Crabtree (2006), the first question is basic with latter questions becoming more specific to ease participants into the conversation. The complete interview schedule can be found in appendix C.

5.6.2 Semi-structured Approach

One can delineate from the previous section on the design of questions and the projects overall approach that the research is utilising a semi-structured interview schedule. The main feature of a semi structured interview is to facilitate the interviewee in sharing their perspectives and experiences (Wahyuni 2012). Semi-structured interviews are a set of standard questions that allow for the addition of questions in response to the flow or themes of the interview (Elton-Chalcraft *et al.* 2008). The exact sequence and wording of questions is set in advance. All participants are asked the same questions and this increases levels of comparability between responses. Data are then complete for every participant. However, an interviewer can still prompt or reiterate questions for data clarity and confirmation (Cohen *et al.* 2011). Questions for participants have to be ‘down to earth’. More specifically, they must be simple, engaging and not elaborate (O'Donoghue 2006).

5.6.3 Conducting the Interview

The conduct of the interview will be based upon best practice as set out by literature. It will also be informed by the project's pilot study. When conducting an interview, numerous behaviours and components have to be noted by the researcher to ensure quality. In light of this, interviewers should have a good understanding of the respondent's language and culture. This is particularly important in specialist areas whereby nuances of language may infer meaning (Gall *et al.* 2007). The project will work with teachers in schools. The researcher is an experienced science teacher with insights into Irish schools and science teaching. In the hopes of building a rapport, this will be explained to interview participants (Gall *et al.* 2007, DiCicco-Bloom and Crabtree 2006) along with the motivation behind the interview. This is mainly because an interview is a social and personal encounter and not just a data collection exercise. The more an interviewer knows a respondent's world, the better data that can be retrieved from prompts and verification. This will

also help prevent self-censoring or socially desirable responses from participants (Cohen *et al.* 2011). DiCicco-Bloom and Crabtree (2006) assert how a safe environment must be created for participants to share their experiences. At the start of an interview, the interviewer must explain briefly the purpose of the interview and how the interview will be conducted (Cohen *et al.* 2011). This is used to help dissolve the initial apprehension of in depth interviews which can characterise the opening questions (DiCicco-Bloom and Crabtree 2006).

Throughout interviews, researchers are supposed to encourage participants to elaborate on answers (Ryan *et al.* 2007). However, the biases and values of the interviewer should not be revealed as this will impact on the participant's responses (Cohen *et al.* 2011). Factual and personal data will be asked at the end of the interview. The interviews will be audio recorded with an iPad as the main source of data logging. This is pivotal as it provides for a complete verbal record of events. Note taking does not allow for a relaxed environment and will be insufficient in capturing the detail of proceedings (Elton-Chalcraft *et al.* 2008, DiCicco-Bloom and Crabtree 2006).

5.7 Observation

Design-Based Research interventions are dynamic and operate in real time (Tabak 2004). This is why the most purposeful method for valid data is direct observation. The investigation of classroom context requires the study of multiple variables. The examination of context requires that the researcher is present. Within DBR, this means the researcher is in the classroom as an observer along with a strong knowledge of how the environment has been 'engineered' (Tabak 2004). Often pedagogical research relies on post-hoc methods such as interviews and surveys. Observation provides a more direct route to obtaining information about behaviours (Millis 1992). Such methods have been adopted by educational researchers to analyse educational practice (Cotton *et al.* 2010, Renninger and Bachrach 2015). Observation is different from interviews and document analysis as it doesn't depend on other people's interpretation of the world. Observation allows the researcher to formulate their own views of events. This provides a more complete description of phenomena than would otherwise be possible (Gall *et al.* 2007). This aids in reducing challenges to validity especially when the observation takes place in natural contexts as opposed to artificial ones (Cohen *et al.* 2011). Observation specifically addresses the gap between what actually happened and how participants describe what happened as discrepancies can often be present between the two (Elton-Chalcraft *et al.* 2008).

This project will employ direct, non-participant observations. The observation is semi-structured in that it has an observation schedule that is flexible depending on the events of that class. The motivation behind this schedule is outlined below.

5.7.1 Observing Affective States

Another vital aspect of the observation approach chosen is that it aids in answering the research objectives. A keystone to the process is the observation of the students' affective states. As noted within the physics hook design, the videos specifically target attention, interest and engagement per theory. The suitability and justification of observation methods to assess the former affective constructs is derived from Renninger and Bachrach (2015). In their recently published work, the prominent authors in the area of student interest and engagement assessed the utilisation of observational methodologies to develop a real world understanding of affective states. The authors present a current gap in research in terms of the examination of naturalistic contexts and interest (Palmer 2009) and engagement (Fredricks *et al.* 2004) as studies are generally experimental (Renninger and Bachrach 2015). This is expanded upon by Linnenbrink-Garcia *et al.* (2010) and Lavonen *et al.* (2005) who posit that relative to the theoretical development of interest, there is relatively little research on contextual classroom factors and their impact on interest within any authentic domains.

Observation methods provide insight into classroom processes that interviews and surveys do not. According to Renninger and Bachrach (2015, p. 66) "This is especially true if the research question concerns the triggering of interest, because the learner may not be aware of the triggering process." Experiences of triggered interest can often be unexpected and participants may not be aware in a reflexive capacity that their interest was triggered. This has implications for self-report measures that are typically used to assess interest (Renninger and Bachrach 2015). Observational methods are the only way to characterise interest and engagement in a naturalistic setting particularly in terms of detail and understanding (Renninger and Bachrach 2015). More specifically, they are necessary to provide essential details when trying to understand processes that take place in the classroom (Fredricks and McColskey 2012, Köller *et al.* 2001). This is vital for the current research as it aims to assess how interest and engagement change based on a student interaction with a designed hook artefact and teacher pedagogies. The examination of constructs in naturalistic contexts is vital to learning how they can be sustained throughout instruction. The observational process also aligns with the iterative revisions within the DBR process. They state,

“observational methods provide a starting point for looking closely at learning activities and their structure, and for possibly noticing new indicators on which to focus” (Renninger and Bachrach 2015, p. 62). Moreover, it is positioned that the insight gained through observational methods is generally of more value to educators since they are concomitant with an insight into context (Fredricks and McColskey 2012, Renninger and Bachrach 2015). Again, this supports the goals of DBR in creating theory and design principles that achieve a real-world impact. As a data collection tool, observations are wholly warranted within the research context, not only in relation to the methodological paradigm of DBR, but also the examination of affective states and their interplay.

5.7.2 Observation Schedule

Classrooms are exceptionally busy. Any observer cannot be complacent. It is thought that any teacher takes part in 1000 exchanges with students every day (Wragg 2012). The focus of an observation needs to be set out before it takes place. The biggest question facing a researcher is what should be the focus of an observation? This is deceptively difficult as the ecology of the classroom is rich and full (Cohen *et al.* 2011). Yet, it can be broken down into various constituents such as teachers, classrooms, students and materials (Petty *et al.* 2012b). Due to the aforementioned complexity of classrooms, a formal schedule has been designed (appendix C). This instrument will ensure that specific sections of the class are analysed intensively.

They include:

- **Factual and physical data:** Teacher, Time and day of class, Year, School, Numbers in class (Boys/Girls), Location of class (Lab or classroom/other), Drawing of the layout of the classroom (plan), Specific topic being taught, Hook used, technology used to play hook, Time during class hook was used.
- **Instruction/Pedagogy:** Pre-teaching method, teaching method with/during the hook. Post teaching method.
- **Students’ affective state:** Student reaction just before hook, Student reaction during hook, Students reaction immediately post hook, Student reaction throughout the lesson post hook.

The main choice by a researcher is in deciding what to watch. During an observation, a researcher’s experiences identify certain characteristics as worthy of annotation. A certain amount of discretion must be exercised. However, such discretion has sources of inspiration unique to the researcher (Wolfinger 2002). Due to this, the observation schedule will split descriptive factual data from

inferences, hunches and reflective data. The final section of the observation schedule is open-ended and entitled field notes.

5.7.3 Field Notes

Field notes will be used to accompany the observation schedule. The exact field note taking strategy being employed is a combination of the salience hierarchy strategy and scratch notes as described by Wolfinger (2002) and Sanjek (1990) respectively.

The salience hierarchy strategy involves describing the noteworthy and interesting features of an observation. However, how does a researcher define what is ‘interesting’? This is highly subjective, but should be particular to the research context (Wolfinger 2002). This strategy will note events that come to the researcher’s attention in detail during the observation. This can be seen as biased and that is why it is being combined with the more comprehensive strategy of taking scratch notes.

Field jottings or scratch notes are the basics of notes taking. Human memory is a very poor recording device; therefore, a notepad should be to hand at all times of research. Anything can be written down in these notes and they are written quickly in the immediacy. Key words and sentences can be used to jog ones memory at a later time (Bernard 2002). Scratch notes refer to short notes taken in the field, generally used as a memory jogging instrument for later writing. Scratch notes can often be keywords, letters or symbols (Sanjek 1990). This is a more complete strategy as every event can be logged quickly. However, it is dependent on memory retrieval to be effective. Notes can be written in situ or post facto (Cohen *et al.* 2011), however, it is advised never to sleep on notes, without fully jotting them down as material is forgotten easily (Renninger and Bachrach 2015). The same applies to reflections, they need to be written while events are fresh in the mind (Bernard 2002, Mulhall 2003).

In addition to the former strategies, descriptive and reflective notes will be separated in field notes as in the observation schedule. Bodgan and Biklen (2003) make the distinction between descriptive field notes and reflective field notes. Descriptive notes aim to capture a slice of life. A description of events requires some level of choice and judgement with regard to what to write about, however, the goal is to strive for accuracy. The role of the research is to transmit as much information as possible. Descriptions should not be summative, rather they should take into account every detail of sounds, images and movements. It is advised not to use interpretive words

such as ‘teaching’. The aspects of the teaching should be fully delineated in specific terms. Such abstract terms lead a researcher to glossing over actualities. Descriptive aspects encompass the following categories: portraits of the subjects, reconstruction of dialogue, description of the physical setting, accounts of specific events, depiction of activities and the observer’s behaviour (Bodgan and Biklen 2003).

In contrast, reflective field notes refer to a more personal account of events. They are highly subjective as the emphasis is on emotions, impressions and prejudices. Bodgan and Bilken (2003, p. 114) state to “let it all hang out”. This is akin to a confession in which the inadequacies, likes and dislikes of the research need to be described. The purpose of such is to improve the notes as the researcher plays such a central role in the collection of data (Bodgan and Biklen 2003). The separation of descriptive and reflective notes enhances the validity of the study by providing a self-checking method that can be revisited during the analysis of field notes.

5.7.4 Writing Up and Analysis of Field Notes

Sanjek (1990, p. 97) refers to the process of turning scratch notes into descriptive notes and posits that this “must be timely, before the scratch notes get cold”. Sanjek (1990) highlights examples from other authors of not writing up scratch notes in the same day as they were taken. The overarching result was a significant loss of insight, thoughts, impressions and reflection. The data produced was of a factual nature (Sanjek 1990). The process of turning raw notes into a narrative is reiterated by (Mack *et al.* 2005). Again, it is advised that this completed within 24 hours. Good note taking triggers memory retrieval and this process is more likely to occur in the immediacy. This is also crucial so that anyone can read a researcher’s notes so as to fully understand the researcher’s perspective. Good descriptive notes should delineate what happened and what the researcher learned about a phenomenon, population or setting. Objective observations should be reported separately to interpretations and personal comments (Mack *et al.* 2005).

When analysing field notes, it is advised to start with a scan method. Notes are simply laid out so that a researcher can get a feel for their data. Often during this stage, initial patterns can be noted (Bernard 2002). Patterning and constant comparison go well with the initial data examination as does thematic analysis. The early stages involve a reviewing and coding densely. Dense coding refers to the process of coding every aspect of data rather than choosing what should and shouldn’t be coded in secondary analysis. Key codes are developed and watched to see if they

are further verified or disconfirmed. Themes and patterns can be identified from clusters of events. Next, metaphors and descriptive accounts can accompany codes which can be placed in broad hierarchical groups (Cohen *et al.* 2011). This is the same analysis and coding as will take place for interviews.

5.7.5 Validity

Numerous authors point to the fact that the presence of a researcher in a room conducting an observation will induce different behaviours than normal. (Cotton *et al.* 2010, Cohen *et al.* 2011, Wragg 2012, Petty *et al.* 2012b, Gall *et al.* 2007). Critics of observational methods would assert that the presence of a researcher will influence or change behaviours being studied. The implication is that individuals will behave ‘better’ or in line with what they deem appropriate for their social environment (Monahan and Fisher 2010). In a sense, observers can be seen as a contaminant on a pure social realm, attenuating the validity and reliability of data. Implicit within such an argument is that observations are more prone to bias than another intervention based research methods such as surveys (Monahan and Fisher 2010). The key issue for the researcher is to reduce this disturbance as much as possible. With different types of observation there are researcher roles. They describe how the researcher will act and behave during the observation and run on a continuum from participant to complete observer (Cohen *et al.* 2011). The role of the researcher in this study is that of a complete observer.

Another validity issue is how observations are inevitably selective and prone to bias as a researcher’s attention is limited (Cotton *et al.* 2010). Observational data is heavily subject to interpretation. Observer’s attention is limited with regard to what they choose to see and filter (Mulhall 2003).

In ameliorating bias, a researcher must have an observation focus with which they will look for patterns, regularities and key features (Cohen *et al.* 2011). The key to successful observation is to be as objective as possible (Elton-Chalcraft *et al.* 2008). Observation is described by Cohen *et al.* (2011) as ‘systematic looking’. To create reliable data, a researcher must be as neutral as possible and this is why the observation schedule and field note strategies have been fully set out so as to give a higher level of generalisability across interventions. Such a systematic approach establishes external validity through the plausibility of findings. This will be further enhanced through the creation of what Lather (1986) calls ‘face validity’. All observational records were typed and returned to teachers for verification. This is a recycling process in which both the

researcher and participant agree on the events that took place during the observation, lending further credence to findings.

5.8 Survey Methodology

In the domain of social research, surveys are the most widely applied methodology (Check and Schutt 2012, Cohen *et al.* 2011). Survey research is often employed as it is an efficient method of collecting data from a broad spectrum of participants. Such methods fall into the interpretive qualitative paradigm as there is generally no attempt to control the milieu of random variables present in naturalistic contexts. Consequently, qualitative surveys aim to uncover and establish meaningful variation with a population (Jansen 2010). Many variables can be assessed simultaneously without substantial cost (Check and Schutt 2012). If one examines the health or shopping industries, qualitative analysis in the form of surveys, focus groups and cognitive interviews are commonplace in attempting to improve practice or sales (Sofaer 2002). It has a stigma of being ‘easier’ than other research approaches, however, potential survey errors can be costly and stem from poor question design and the wrong sample of participants (Check and Schutt 2012, Elton-Chalcraft *et al.* 2008). Conducting a research survey of high quality and that is credible requires thought and practice. However, validity within this phase of research is bolstered as teacher records and focus groups are also being utilised to triangulate the data.

5.8.1 Exit Cards

The qualitative survey in this research is a pre-structured (deductive) survey. The survey aims to elicit the diversity of views surrounding the current theory generated in the hopes of further advancement from the student perspective (Jansen 2010). The survey, which can be found in appendix C, is a short qualitative survey containing two questions. It is based on a qualitative strategy utilised by Mitchell (1993) in his investigatory assessment of situational interest in the classroom. In the authors survey, students were asked to list aspects of their lessons they found interesting. They were then asked to describe why they listed topics in certain sections. The survey instrument in this research follows a comparable line of questioning. It not only provides potential confirming evidence of hooks creating interest in class, but also exploratory data on why this may be the case. The first question is a closed question and asks “What was the most interesting thing about the lesson?” This is a confirming question based on results of the previous two phases. It is simply employed to highlight the part of the lesson students find most interesting. The second question is open-ended and asks for a justification of the first question. It asks; “Why?”. The

rationale is to gain an insight into the students thought processes in terms of what they see as interesting and valuable in that particular science lesson. As students quantify their answers to the first question, this will enable the examination of the complex phenomena present in class in their language (Barker *et al.* 2002). Open questions like this are often used to measure interests, opinions, preferences and experiences and will provide an insight into a respondents thinking at that particular moment in time (Thomas 1999).

A survey design consideration noted by Thomas (1999) is how long it will take the respondent to provide a response. As can be noted from the survey, it is purposely designed to take less than five minutes. Teachers have been asked to administer the survey to students (upon receiving relevant permissions) during the last five minutes of class in which a video hook was utilised. The researcher is aware of how introducing a survey instrument could impact on the authenticity of the classroom context. Hence, the survey is being utilised and described to the students as an exit card. Exit card strategies are commonplace in classrooms and should be easy for the students to understand and answer (Klein *et al.* 2015). Generally, exit cards pose a question at the end of the class and the students response is then written on the card. The card is anonymous and handed to the teacher as the students leave the classroom (Wylie *et al.* 2009). They are a simple and efficient way to collect classroom evidence (Barker *et al.* 2002), while also being a safe and unobtrusive way for students to voice their opinions (Owen and Sarles 2012). Many students in the study will already be used to this sort of assessment in class. Therefore, the surveys impact on the classroom should be minimal (Gall *et al.* 2007).

The exit card strategy was not piloted, due to time constraints in design cycle 3 and the practical consideration of a fluctuating methods pool due to mutations (Hoadley 2004) in the hook design. However, the design of the exit cards follows recommendations in the literature and is a minor adaptation of Mitchell's (1993) qualitative instrument used to ascertain students' interest. By extension the researcher argues that the exit cards represent a robust and valid method of student assessment.

5.9 Group Interviews

Group interviews are being utilised as a research tool to gain an insight into student opinions pertaining to the physics video hooks. The group interview methodology was selected as it can add considerable amounts of depth and richness to data in an efficient manner (Frey and Fontana

1991). Group interviews provide a different viewpoint, that of group consensus or lack thereof. Groups create their own structures and levels of meaning. Often, they can clarify arguments and reveal a diversity of opinions (Frey and Fontana 1991).

In terms of students, group interviews can take place with an entire class, however, usual protocol dictates between four and six people (Denscombe 2014). This helps limit the amount of voices that can contribute to the discussion at any one time (Frey and Fontana 1991). Typically, four to six group interviews are conducted as data becomes saturated and new groups produce little new information (Morgan 1996). Within this research, the aim is to conduct eight group interviews, two in every class during design cycle 3. Four students form the participants in each group interview. The composition of the groups is random barring that every group has two male and two female students. The group interview schedule employs a semi-structured questioning scheme that addresses students' perceptions of the hooks in general while also tackling areas such as hook design, pedagogy and how the video impacts them personally in the classroom and beyond (appendix C). A semi-structured approach to questioning was implemented as this allows questions and procedures to be highly adoptable and evolve based on participant contribution. A strict questioning schedule allows for a high level of comparability across groups. However, this would disadvantage research examining exploratory or variable opinions (Morgan 1996) as is the case in this project.

The group interviews were not piloted, in line with the previous justifications for the exit card strategy. However, the researcher has already conducted numerous interviews with teacher participants and is an experienced teacher. Hence, it is positioned that the group interviews will be conducted in a fair and valid manner. Moreover, the iterative design allows for changes in the schedule/procedure if it arises as a necessity throughout design cycle 3.

5.9.1 Procedure

Before the group interview takes place, the primary researcher will introduce themselves to the class and reiterate the purpose of the research (students will already be aware of the project, as they will have each read the relevant information sheet and informed assent for the interview strategy). Students will be given an opportunity to ask questions or withdraw from the study at this point. After that, four students will be randomly selected from the group. The group interview will not take place in the classroom, it will take place in another pre-arranged room on school grounds.

The group interview will take approximately thirty minutes and teachers will be asked to support students in the lesson content they will have missed.

During the group interview, the primary researcher will again introduce themselves and the project, giving the students the right to withdraw and inform them again that the interview will be recorded. Students will be allowed to decide on their own pseudonym (within reason) for the interview and respective name badges will be given. After this, one of the video hooks that the students have observed will be played again. Students will then be asked questions by the primary researcher that will follow the group interview schedule guide in appendix C. It should be noted that other ancillary questions or discussion topics may arise during the interview process.

Pertaining to permissions and anonymity, the project will initially obtain permission from schools by having a meeting with co-operating teachers and relevant staff. With this permission, an informed consent letter will be sent to all parents/guardians of students involved in the study. This letter will be endorsed by the school. Upon receiving consent by parents/guardians, the children themselves will be asked for their assent to be part of the project with an informed assent letter. Students who do not consent or who do not receive consent will remain part of the class, but will not be asked to take part in the group interview.

5.9.2 Validity

In terms of validity of group interviews as a research tool, one issue is that the group may only express what is deemed to be ‘acceptable’ opinions and steer clear from more controversial issues, however this should not be an issue with this research as it does not examine a sensitive or controversial topic (Denscombe 2014). Yet, researcher must be aware that students may express inauthentic opinions as there are powerful differential when interviewing children (Creswell and Miller 2000, James 2007). Indeed, this brings to the fore the role of the researcher in the group interview. The researcher provides a platform and structure for the discussion to take place (Elton-Chalcraft *et al.* 2008). Groups in which the interviewer exhibits a high level of control are termed ‘more structured’. It can be structured with regard questions or managing group dynamics, for example, attempting to get all parties to contribute equally. A more structured session is a potential sign of a researcher pursuing their own interest as opposed to the groups (Morgan 1996). This is something that will require continuous appraisal within the group interviews and is dependent on

the skill of the researcher since every group interview, as a social encounter is wholly different. Therefore, the balance that is needed will be judged on an interview by interview basis.

Finally, the argument can be made that the interview procedure within this study can be classified as a group interview as opposed to a focus group due to the smaller number of participants (Denscombe 2014). Focus groups have a larger number of participants and generally cover more controversial topics (Kitzinger 1994, Kitzinger 1995). Due to this, they explicitly look for varied opinions along with an interplay of dialogue between interviewees (Frey and Fontana 1991). Both approaches have similarity, but for working with small numbers of students on non-controversial topic, group interviews are a more appropriate method.

5.10 Teacher Journal

Teachers in the third phase of research are asked to maintain a short and simple teacher record for every hook intervention that took place. This is a triangulation instrument to corroborate the students' feedback from the group interviews and exit cards. The recording instrument provided for the teachers asks them to detail, what hook was used, when it was used and what teaching strategy was employed in association with the hook. Furthermore, teachers were asked to describe the student reaction to the hook video and they were asked to leave any other feedback or comments they wished. The teacher record can be found in appendix C.

5.11 Research Journal

Throughout the course of this research, the primary researcher will be keeping a research journal/log to act as a chronicle for every event that takes place during research with participants. A reflection will be written after every interview and observation. Furthermore, the research journal will be used to make note of any interpretation or hunches of the researcher with regard to research questions or theory.

The journal keeps a reflective and literal record on ideas and events throughout work. It helps develop and cultivate ideas within a project. It serves as a memory aid (Cohen *et al.* 2011). Journaling refines the understanding of the role of the researcher within a qualitative study as well as responses from participants. Within qualitative research, the researcher and participants are the research instruments (Janesick 1999). "It is a great vehicle for coming to terms with exactly what one is doing as the qualitative researcher." (Janesick 1999, p. 507). Writing a journal is a precision method and lets the researcher get feedback from themselves in a full and open-ended manner.

Keeping a journal allows a researcher to triangulate data and examine their own interpretations through logical means. Such an aid to retrospective analysis is a key element of design and DBR. Certain elements of design are implicit, however, as Edelson (2002) notes, they must be made explicit and open to criticism within research.

5.11.1 Reflexivity

Another characteristic of qualitative research is that the researcher becomes the research instrument for data collection and analysis (Merriam 2002). A human instrument is adaptive and responsive both in the immediacy and long term (Ortlipp 2008). However, the major shortcoming is the inherent bias in this process. Rather than trying to eliminate bias in interpretive research (Sochacka *et al.* 2009), the qualitative researcher identifies them from the start of the project (Merriam 2002). Examining one's own interpretations and biases allow the research to surmount the problem of reflexivity (Dowling 2006). "Reflexivity starts by identifying preconceptions brought into the project by the researcher, representing previous personal and professional experience" (Malterud 2001, p. 484). Reflexivity ensures the researcher examines their interleaving assumptions, goals and ideas over time (Ortlipp 2008). Further, reflexivity requires researchers to be aware on multiple levels of relationships and products of the research (Dowling 2006) as the researcher in qualitative studies is the core 'CPU' that computes all data. Meanings developed in social contexts require negotiation to unveil more valid insights (Finlay 2002). Therefore, reflexivity is the objective march toward neutrality of analysis and justification of interpretations (Finlay 2002).

Reflexivity is different from direct reflection. Reflection refers to an in-depth examination of a past object or event, however, reflexivity refers to a state of neutral and non-biased mindfulness that a qualitative researcher desires (Finlay 2002). Reflexivity is a continual process embedded on a continuum, however, reflection as a learning tool can aid the reflexive process (Dowling 2006). The maintenance of a research diary enables the interpretations and representations of data to be credible and trustworthy (Malterud 2001, Sochacka *et al.* 2009). As noted, this will be conducted as a self-checking mechanism to increase the rigor of the study.

Combined, reflexivity and reflection are core facets of the DBR process. Throughout an iteration, results must be allowed to 'settle'. The interplay of a complex classroom setting is not intuitively obvious and should not be treated in this manner. That is, in the case of DBR, the researcher must examine the intervention from a number of angles and rationalise why particular

parameters were effective and others were not. The direction a project follows throughout cycles is a manifestation of the researcher's agenda and as such it must be evidence driven (reflection) and neutral (reflexivity) (Finlay 2002). Throughout the recursive DBR progression, transparency and rigor was ensured as the researcher worked as a part of a team of Design-Based researchers and was active in STEM outreach. With this, the researcher regularly consulted with team members and associates to critique interpretations of the data. Additionally, the research was disseminated to a wider audience: internally, through annual presentations to a graduate research committee, educational reading groups and university research seminars. Externally, research was disseminated nationally and internationally, through conferences and peer reviewed publications. All critique and feedback was used to continually drive forward the credibility of the research.

5.12 Sampling Method - Overview

Interventions within this research are defined by a teacher in a school, whereby each teacher relates to a particular class group. It was decided that teachers needed to be recruited to the project in a systematic and fair manner. However, candidates to partake in research should be chosen in light of answering the research questions (Morse *et al.* 2002, Yin 2014). The research questions circulate three themes, application of hooks, design of hooks and student reaction to hooks. Teachers and students are the information rich candidates who can provide in depth answers to the research questions within this study.

When selecting participants for the study, a sampling scheme was developed. Sampling schemes are specific techniques that are employed to select units. However, sampling designs refer to the framework in which the sampling occurs. It comprises of the complete number of sampling schemes and sample size (Onwuegbuzie and Leech 2007). The sampling scheme was any junior science teacher in Ireland. Within this remit, the study is adopting an eclectic sampling approach that includes theoretical and purposive techniques. Theoretical sampling seeks out participants who have desired information. Participants are selected based on their ability to contribute to the generation of knowledge (Cohen *et al.* 2011). It allows the researcher to answer the research questions more efficiently (Guest *et al.* 2006). Purposive sampling is a method in which information rich participants are selected (Petty *et al.* 2012b). These participants are the ones most likely to answer the research question (Gall *et al.* 2007). Such strategies can be used in isolation as well as in combination and this contributes to triangulation (Cohen *et al.* 2011).

Science teachers have both the relevant knowledge and experience of instruction and the learning sciences. After ethical approval in October 2014, the sampling strategy with the target audience was implemented. A number of strategies were employed. Every county in Ireland with an established Irish Science Teacher Association (ISTA) branch was contacted and asked to distribute an introductory email and flyer. The Irish Institute of Physics (IOP) was contacted and asked to disseminate details among their members. The introductory email and flyer were distributed throughout Ireland's largest forum for science teachers 'SharingScience'. The Professional Development Service for Teachers (PDST) placed the flyer on the news feed for science teachers. Flyers were distributed during the Galway Science and Technology festival in November 2014 as well as placed upon the Galway Science and Technology festival social media sites. The introductory email and flyer are in the appendices (appendix B).

The estimated sample size in this project is six – eight teachers (Sobal 2001). With regard to sampling numbers, there are three main school types in Ireland: voluntary secondary schools, vocational and community colleges and community schools. The project will endeavour to work with at least two teachers from each of these schools. From these two teachers, it is endeavoured to have both male and female teachers represented. Although the research is not specifically looking at a gendered analysis, where any gendered issues should arise, they will be considered. It is in this vain that the project is open to the possibility of ancillary conditions becoming central to findings. This is why the current sample approach is being used.

Pertaining to a sample size of 6 - 8, Guest *et al.* (2006, p. 59) states that “guidelines for determining non-probabilistic sample sizes are virtually non-existent”. There are no set rules when determining the number of participants in qualitative studies. It is a matter of judgement and seen as a trade-off between breadth and depth. Since the project is qualitative, the focus will be on depth and detail. Qualitative research is typically reliant on the concept of saturation. Saturation refers to the point at which data provides no new information of merit or quantity. However, the concept of saturation provides little help in determining sample sizes prior to research (Gall *et al.* 2007).

5.12.1 Sampling

Sampling is a contentious and complex issue in qualitative research as there are many overlapping types of sampling (Whittemore *et al.* 2001). Purposive, theoretical and to a lesser degree deviant sampling (Barbour 2001, Morse *et al.* 2002) are employed in this study so as to contribute to

triangulation (Cohen *et al.* 2011). This demonstrates a reasonable level of representativeness and a strategic approach to research (Cohen *et al.* 2011). Qualitative research is concerned with ensuring representativeness and appropriateness of a 'good' informant (Coyne 1997). However, the main aim of sampling in qualitative inquiry is not to achieve total representativeness but acquire a level of representativeness for similar populations. Qualitative studies attempt to catch the breadth and depth of the population it examines (Cohen *et al.* 2011). This is seen as a trade-off and a matter of judgement. Depth refers to scrutinising the experiences of a small sample in great detail. Yet, a larger number of participants can be beneficial in the study of diverse phenomena (Gall *et al.* 2007). Extensiveness in qualitative studies represents the amount of information gathered. Extensiveness is a multidimensional construct that is important for all types of data collection (Sobal 2001). The concept of extensiveness can be broken down into both the sample and amount of data. They are both inextricably linked. In determining when a study has reached the limits of its extensiveness saturation is a concept used to aid researchers.

5.12.2 Saturation

The guiding principal for sampling in qualitative research is that of saturation. Saturation is important due to the law of diminishing returns (DiCicco-Bloom and Crabtree 2006). As a study progresses, more data does not mean more information. Within qualitative research, particularly when using interviews, various opinions exist and will be uncovered. The complete diverse range of opinions must be completely uncovered and this point is saturation. Certain factors influence how quickly or slowly a researcher hits the point of saturation. It is suggested that a small study with a limited scope would reach saturation faster than a large study that is multidisciplinary (Sobal 2001). With a homogenous sample and a tightly focused research agenda, a small sample size of twelve has been shown to reach saturation when using semi-structured interviews (Baker *et al.* 2012). Saturation along with replication will mean that sufficient data has been obtained to account for all aspects of the phenomena being studied (Morse *et al.* 2002). It is suggested by Sobal (2001) that six to eight sources of data are sufficient when employing individual interviews with homogenous participants. Twelve to twenty are needed to achieve maximum variation (Sobal 2001). The question remains, however, how does a researcher prove that saturation has been reached? The concept of saturation provides little practical guidance prior to sampling (Mason 2010). Within literature, there is a dearth of research on how and when saturation is reached. There are no guidelines or tests of adequacy (Guest *et al.* 2006).

Theoretical saturation in qualitative assessment refers to data that no longer provides new, relevant or emergent categories suitable for coding. Once no additional categories are warranted to explain phenomena and the relationship between the categories appear well established and valid, theoretical saturation has been reached (Gall *et al.* 2007). When categories are involved, theoretical saturation refers to no new information emerging in any category and this will be used as a guide for semi-structured interviews, group interviews, and observations during the mainstreaming and capstone phases of this research. The pilot phase is, by nature, is smaller in scale and investigative rather than seeking theoretical saturation.

5.12.3 Sampling in Design Cycles

5.12.3.1 Design Cycle 1 – Pilot

Design Cycle 1 was deployed with a purposive sample of two pre-service science teachers. It was decided to work with these teachers as a proxy for in-service teachers so as not to take from the potential pool of science teachers that would be recruited in other phases of the study. The pre-service teachers were recruited from the 2014/2015 Professional Masters in Education (PME) in the National University of Ireland Galway. An email was sent to all students asking for two from the cohort to participate.

5.12.3.2 Design Cycle 2

In Design Cycle 2, ten secondary science teacher participants across Ireland were recruited for the study using a theoretical and purposive sampling strategy. An email and a flyer were used to recruit the participants. In total, eleven teachers responded with one teacher not partaking due to medical reasons. The teachers came from a variety of schools including vocational, community college and voluntary. Four male and six female teachers took part in the project with varying levels of experience. Five of the schools were co-educational, four were all-girls schools and one was an all-boys school.

5.11.3.3 Design Cycle 3

In Design Cycle 3, four of the ten teachers that completed design cycle 2, were asked to take part in the final phase, two male and two female. These teachers were approached as they have the relevant knowledge of the hook videos and pedagogy. In addition, these four teachers utilised the widest variety of teaching strategies in Design Cycle 2. This aligns with the theoretical sampling strategy employed within this research. Furthermore, they did not require any ‘upskilling’ for this

phase. Moreover, teachers selected for the third phase of research were the ones who engaged the most with the video hook technology as discerned through the entire intervention and data collection processes. Adding credibility to this decision, four teachers were selected for this phase as the research would mainly be working with their students. The principle of saturation was applied in estimating how many student responses would be required for the exit cards and group interviews. The research method will generate approximately 200 student responses. Pertaining to group interviews, an initial estimate of eight interviews was employed with the potential for more of saturation had not been reached.

5.13 Ethical Considerations

Ethics is a sub section of the philosophy concerned with how people should act toward one another (Cohen *et al.* 2011). Ethics are grounded in judgements and values, which in turn are developed through one's own and societies set of morals. In a research setting, ethics sets out the rules and policies for conducting studies within the boundaries of a proper manner (Gall *et al.* 2007). In a quantitative context, ethics plays less of a role over qualitative, especially in educational settings. Quantitative work is positivist and impersonal. Any ethical considerations surface during the design phase and are readily corrected. However, qualitative studies are far more complex as they often require a more probing relationship between researchers and participants. This is the case in this research (Gall *et al.* 2007, Elton-Chalcraft *et al.* 2008). Qualitative research is also more open-ended. That is, it is less predictable than quantitative research as unknowns may develop throughout the course of the investigation. Planning research is the first step in avoiding ethical pitfalls. Care must be taken in the design stage to address the possible beneficial or negative outcomes of any project on both the researcher and participants (Gall *et al.* 2007).

All ethical considerations within this project have been made with constant consultation with World Health Organisation (WHO) ethical guidelines and the British Educational Research Association (BERA) ethical standards. The project received ethical approval from the NUI Galway Research Ethics Committee on the 23/10/2014.

Participants in this study comprise of teachers and students. However associated participants include, parents/guardians and relevant school staff. All research participants will be made fully aware of the purposes, risks and potential reward of the research (Gall *et al.* 2007, Cohen *et al.* 2011). Participant information sheets, consent and assent forms are in the appendices

Chapter 5: Methodology

(appendix B). The video hooks are non-controversial and do not represent any threat to any participants. The video hooks are of various scientific phenomena and can be viewed online at <http://www.sciencehooks.scoilnet.ie/>

Working with teachers forms the majority of the research. Requests for meetings are set out above in the various strategies employed to make initial contact with teachers. The researcher then visited any teachers who were interested in being participants in their schools with the principal by arrangement.

In this meeting, every participating teacher and associated principal was given the full details on the study. Teachers who are interested in partaking will be given an informed consent form for permission to observe and partake in an interview. Teachers were also given an implied consent form for students to bring to their parents and an assent form for students. This was to allow the observation to take place in an ethical manner. All forms are contained in the appendices (appendix B). Teachers will be given a 'teacher pack' which fully explains the science and motivation behind the videos as well as a digital copy of the videos. Verbal consent will be continually sought throughout the course of the investigation (DiCicco-Bloom and Crabtree 2006, Harcourt and Conroy 2005). A plan of action will be made during such a meeting regarding to dates of observations and the extent of work.

With this contact information, all parents/guardians will be sent a letter containing an implied consent form for their child and an information sheet. This will be sent out one month prior to the commencement of the research to allow apt time for consideration and response.

The students in the study will also receive an assent form and an information sheet one week in advance of the observation. It will be handed out by the teacher. This will also serve as a reminder to parents regarding the upcoming research. Students who opt out of the study or are refused permission by parents/guardians will remain in the class. However, none of their input into the class will be used as part of the study in any fashion. They will remain part of the class during the study. This will be discussed when meeting with principals. Other options involve students being transferred to another science class for the duration of the one lesson observation, although this option would not be favoured.

All participants have the right to participate freely and voluntarily with the right to comfortably withdraw without penalty. Rights to privacy and confidentiality will be honoured.

Any names mentioned within audio recordings of teacher interviews will be changed and no dissemination of audio will take place (Ryan *et al.* 2007).

With regard to maintenance of privacy and confidentiality, participants will be informed of those (researcher and supervisor only) who will have access to their information and no unauthorised person will have access to data. Pseudonyms, codes and numbers will be used to mark responses and identities. The computer will also be password protected.

Regarding parents/guardians, a process of informed consent will be used. The idea behind implied consent is that “children may participate unless their parents provide written refusal” (Unger *et al.* 2004, p. 52). According to Unger *et al.* (2004) implied consent is appropriate when research presents minimal risks to the student. However, active written parental consent is warranted when research imposes additional risks above those already encountered in everyday life. We would argue that this research does not incur any additional risks above what the students would usually encounter and this has been supported by the NUI Galway ethics committee. With implied consent, the students’ parents/guardians are asked to sign and return a refusal form only if they do not want their child taking part in the study. If parents do not return the form, it is assumed that informed consent has been granted. Additionally, active written parental consent is notoriously difficult and often impractical to obtain with large amounts of students which this study will have (Esbensen *et al.* 2008).

The data will be kept until 5 years after the successful submission of the PhD as agreed by related examiners for the verification of findings, after this time, it will be destroyed. Complete data will be stored on an external hard drive and deposited in a locked drawer in Dr. Veronica McCauley’s office, GO19, CIMRU, Nuns Island, Galway City, Co. Galway. Data will be wiped from all electronic sources (DiCicco-Bloom and Crabtree 2006). Physical data will be shredded and disposed. No data will be sent via email or stored in online databank services.

5.13.1 Incentives

With the goal of maximising response rates and participation in research, incentives play a pivotal role (Cohen *et al.* 2011). Throughout the design phases incentives were used. Firstly, in design cycle 1 (pilot) the pre-service teachers were given lesson plans and teaching resources relevant to their subject areas. They were also given a book as a gesture of gratitude. Secondly, in design cycle 2, teacher participants were entered into a draw for a Celestron Astromaster telescope. The winner

was contacted and the telescope was awarded in June 2015. All other teacher participants in this phase received a book and a card as a gesture of thanks for their participation. During design cycle 3, four teachers from the previous cohort were recruited. As an incentive they were all given a book and a €50 gift voucher.

5.14 Analysis

Data analysis involves the transformation of raw data into narratives, descriptions and themes. There is considerable variation in how this is achieved. Concurrent collection and analysis enhances credibility (Ryan *et al.* 2007). This is core to the qualitative inductive processes that will be implemented throughout the course of this research. This is one of the major hallmarks of qualitative inquiry. Data is analysed continually from initial conception to in depth analysis (Savenye and Robinson 1996). Analysing emergent data is typical procedure during qualitative studies (Yin 2014) and therefore aligns well with this project. This will help determine subsequent data collection techniques or modifications thereof (Gall *et al.* 2007). Qualitative data requires the researcher to make sense of all evidence collected to gain an organised and conceptual view of data (Elton-Chalcraft *et al.* 2008).

5.14.1 Data Analysis

Data analysis in quantitative research is time consuming and laborious. Typically, data analysis and collection occur at the same time. This demonstrates the iterative nature of qualitative research. Data is usually in the form of words that require interpretation (Petty *et al.* 2012b). The analysis framework employed in this research study takes mostly from thematic analysis methods, however, this has been supplemented with additional phases to ensure that the rigour, validity and quality of assessment are more readily achieved. Moreover, a more structured audit trail is developed with this type of analysis framework. The following describes every step taken during the data analysis process. Although presented as a linear fashion, the research analysis is a flexible progression (Fereday and Muir-Cochrane 2008).

5.14.1.1 Thematic Analysis

Qualitative analysis approaches are highly diverse, however, thematic analysis is one of the most commonly used methods. Thematic analysis “is a method for identifying, analysing and reporting patterns (themes) within data.” (Braun and Clarke 2006, p. 79). It is distinct from other analytical methods as it seeks to describe patterns across all data (Braun and Clarke 2006, Fereday and Muir-

Cochrane 2008). It organises data and aids in interpreting various aspects of the research topic. It is a theoretically flexible method and therefore it is utilised in a variety of projects (Clarke and Braun 2013). The varied and open application arises from its focus on analytical procedures, coding and theme development (Braun *et al.* 2014). This is a hallmark feature of thematic analysis and means it can be applied to a plethora of qualitative research projects (Braun *et al.* 2014). Thematic analysis focuses simply on the analytical sections of a study. In utilising this method, a researcher must know the ontological and epistemological frameworks that underpin their research. In addition, they must choose whether to use an inductive or deductive coding approach (Braun *et al.* 2014). Within this research, a deductive approach to coding is being implemented. This aligns with DBR methods as theoretical considerations are built into a design artefact before the collection of data. This study already has a focus on particular theoretical stances and they form the base for the creation of conceptual/pre-codes to guide analysis. However, this is not to say that new codes which emerge from the data are ignored, they simply emerge within a pre-developed framework.

Braun *et al.* (2014) present an iterative and flexible six stage approach to thematic analysis. The analysis procedures within this research followed the recommendations, however, other steps were also employed based upon recommendations from other authors to create a hybrid approach to data analysis. The process manoeuvred through various levels of abstraction which emphasised the evolution of interpretations and descriptions to higher logic levels. The adopted approach being that of creating codes, categories and themes (Graneheim and Lundman 2004). Embedded within a thematic framework, the precise amalgam analysis method will be illuminated presently. This process was instigated throughout all design phases.

5.14.1.2 Pre-coding

Pre-coding is a process of predicting codes that the researcher believes will appear in the data. According to Miles and Huberman (1994, p. 65) pre-coding “forces the analyst to tie research questions or conceptual interests directly to the data.” Its function is to remind the primary researcher of the many influences behind research questions and potential biases . Pre-codes are derived from research literature, previous studies and researcher hunches. A collection of codes can be collected and applied as the key thematic ideas when they become apparent within the data (Gibbs 2008).

In this study, a number of broad codes were derived from the research questions and the theoretical underpinnings of this thesis which arose before the inception of data collection. The pre-codes are presented in Figure 5.3.

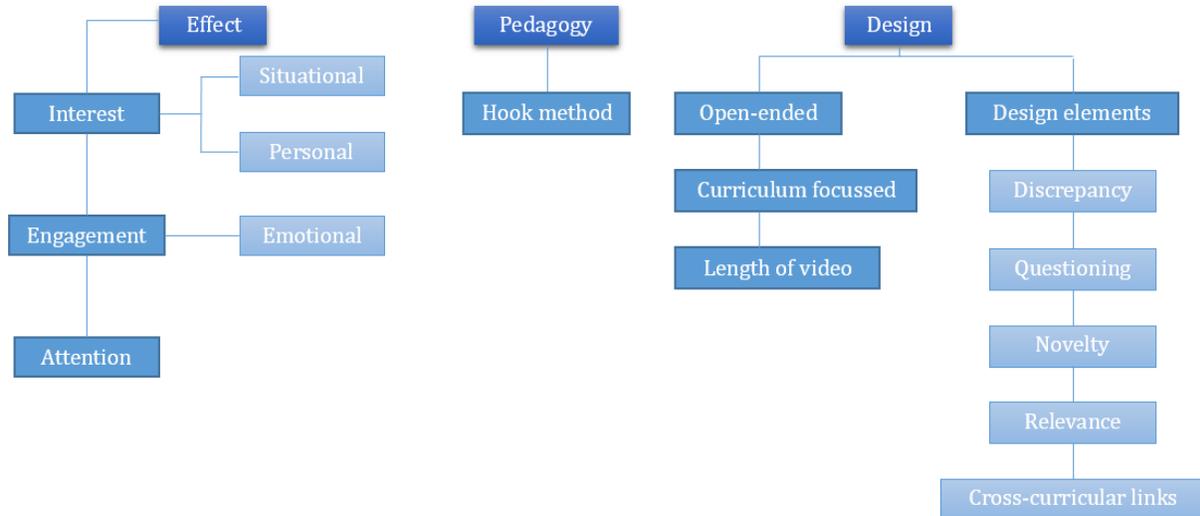


Figure 5.3: Pre-codes created for data analysis before the initiation of data collection

5.14.1.3 Familiarisation

Upon attaining data, the next phase is familiarisation. This is a common trait across many qualitative research analysis approaches. This is a process of immersion where data requires reading and re-reading to create an initial analytical engagement. This is a starting point in which a researcher begins to note points of interest (Braun *et al.* 2014).

The process of familiarisation continues throughout the transcribing process, albeit at a deeper level. Familiarisation is vital as this is the first crucial step where there is potential for massive data loss or distortion (Elton-Chalcraft *et al.* 2008). The main issue when transcribing is that interviews becomes data when originally they were a social encounter. Audiotape neglects visual and non-verbal factors. This is why transcription inevitably loses data as the direct link between the researcher and the participant is lost. The encounter is frozen in written language. Therefore, it is advised to take note of the mood when comments are being made. Often, inflection, tone and speed of speech administers new meaning to a sentence (Cohen *et al.* 2011).

Familiarisation and having an understanding of the interview as a social event is vital in deriving credible meaning from participants.

5.14.1.4 Analytic Memos

The next step is the writing of analytic memos. Thematic analysis requires constant reflexivity in examining coding procedures (Rohleder and Lyons 2014). Aiding in the reflexive process of familiarisation, analytic memos can be utilised to develop initial interpretations of research findings. This involves writing memos that describe initial interpretations on sections of data. Hence, leading raw data to initial abstraction, idea generation and deeper analysis (Saldaña 2012). Analytical memos were written about every aspect of data. An example of the analytical memos developed is presented in Figure 5.4. The process was conducted in Microsoft Word 2016 using the 'New Comment' function to place an analytical memo on the right-hand side of the page that was directly linked to the data.

Chapter 5: Methodology

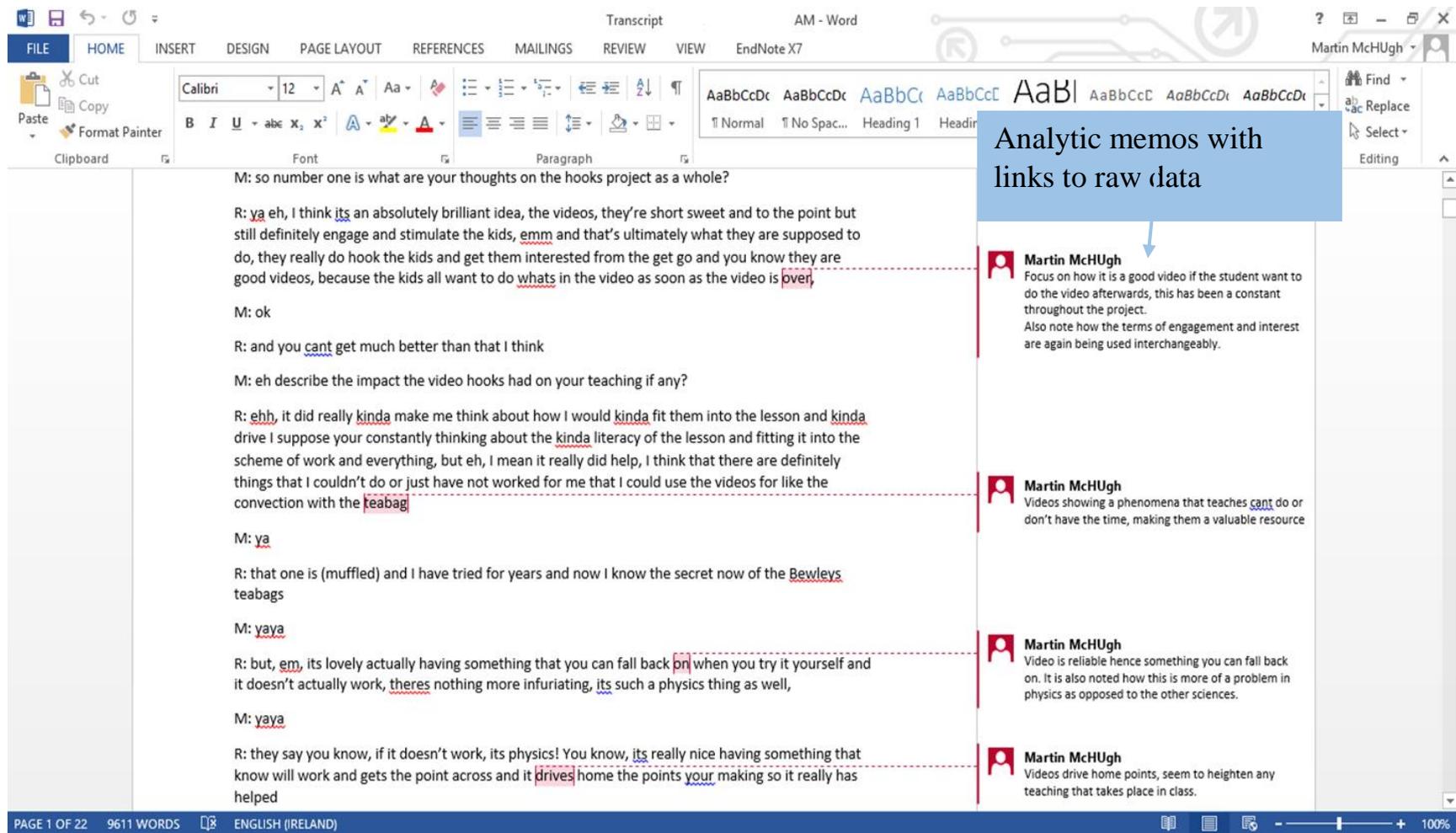


Figure 5.4: Screenshot of analytical memos being written in association with a transcript using the comment function in Word

5.14.1.5 Coding

After the creation of the analytical memos the next process involves the first cycle coding of the data. Coding is a process of organising the data within transcripts so patterns can be discovered within the structure (Auerbach and Silverstein 2003). This involves moving away from raw data to abstract theories with small progressive steps. These steps are called codes (Auerbach and Silverstein 2003) which “form a focus for thinking about the text and its interpretation” (Gibbs 2008, p.40). During coding, the goal is to learn from data so the researcher can gain an understanding of patterns and theories by ascribing codes or numbers to categories of data (Elton-Chalcraft *et al.* 2008). This is highly interpretive and may be subject to bias as the researcher decides the focus. Moreover, coding and sorting provides a dilemma as a social encounter becomes fragmented and atomised. When entering the coding process, incubations are recommended to reflect on data so initial and impulsive perceptions are not biased (Savenye and Robinson 1996). To further reduce bias, it is suggested to listen to the interview on a number of occasions to get a feel for the data per the familiarisation process (Cohen *et al.* 2011).

Coding involves the scanning of data and forming categories that are easily stored and retrieved. It is a highly variable process in any given study (Savenye and Robinson 1996). Multiple coding techniques can be used and this involves cross checking of coding strategies and interpretations by the researcher. This is costly in terms of time and effort, but can be a valuable strategy even only if certain sections are re-examined. Many researchers find different meanings in data and this is not surprising given the complexity qualitative data sets (Barbour 2001). Coding is a difficult process and is open to interpretation. When comparing codes, sections that require a code are assigned a number or acronym (Gall *et al.* 2007). They are then compared with codes across the entire data set to observe any patterns or relationships. Codes are grouped to create a smaller number of categories. Key themes slowly become distilled from this process which Petty *et al.* (2012b) states is non-linear.

During this process, coding brings together similar and dissimilar aspects of data so that they can be reviewed (Richards 2009). Several passages can be identified through codes and linked to the same idea. The code being the common identifier in the data. Codes then act as an index of ideas to facilitate the establishment of a frame of reference in the analysis phase. Gibbs (2008) employs both paper and computer based approaches. The former allows for creativity and

flexibility during the early stages of research. To continue the analysis, the initial paper based codes can then be transferred onto an electronic format (Gibbs 2008). This was the strategy employed in this research project. First cycle coding was conducted manually, while second cycle coding was conducted using NVivo 10.

5.14.1.6 First Cycle Coding

As noted, first cycle coding was conducted manually. It is recommended to initially manually work through the data rather than using software from the start of a project. This is so the researcher can develop basic qualitative analytical skills and gain an insight and understanding of their data (Saldaña 2012). First cycle coding represents a systematic process in which codes are developed from the dataset. The coding process employed in this study was a semantic process using descriptive methods as described by Saldaña (2012). The exact coding methods instigated were elemental methods along with some scope for holistic coding after the initial analysis was complete. This was necessary due to the sheer volume and density of codes. This method was also used as it aids analysis across numerous types of data, including interviews, reflections, observations, surveys and field notes (Saldaña 2012). Descriptive coding formed the basis of coding. This is a summarising technique that assigns words or phrases to portions of text (Saldaña 2012). As noted by Saldaña (2012, p. 70), descriptive coding assigns a “basic vocabulary” to the data. It provides a foundation for further inquiry. However, the descriptive coding was loose in that it allowed for more analytical coding at times when which interpretation was vital to assign meanings within the data (Richards 2009). The second elemental coding method implemented was process coding. Process coding uses ‘doing’ words or gerunds to denote a process within the data. This was deemed appropriate for this project since the initial research questions assesses a complex authentic environment, that of the classroom concomitant with action. Hence, this proved to be a fruitful initial coding method. The third elemental method employed was ‘In Vivo’ coding. This method was used least, but provided key insights into the data and the participant’s feelings. In vivo codes take a word or short phrase from participants themselves. An example of which would be ‘Over their heads’. This in vivo code was used by a number of participants to describe when students found an event confusing or too high an academic level for the ability. This method is used to keep a connection to the participants and the raw data they provided as utilising a participant’s words may enhance and deepen the researchers understanding of the data (Saldaña 2012). In sum, the three strategies formed the basis of the first cycle coding. This is an

Chapter 5: Methodology

advantageous strategy as multiple coding involves the cross checking of coding strategies and interpretations by the researcher. This is costly in the remit of time and effort, but can be a valuable strategy in reducing bias (Klieger *et al.* 2010, Sofaer 2002). First cycle coding was conducted in Microsoft Word 2016 (Figure 5.5).

Chapter 5: Methodology

The screenshot shows a Microsoft Word document titled 'CODER (CB) - Word' with the 'TABLE TOOLS' ribbon active. The document content is a transcript with red-coded text and a table on the right. Blue callouts point to 'Data', 'Number', and 'Code' elements.

R: would be to put it in with <u>ehm</u> and activity at the beginning and I love the idea of the video being open <u>16</u> , like you hold their attention <u>17</u> , if you pause the video <u>18</u> , we are going to see then end of that, if you guys get this right and I think, the video is so nicely produced <u>19</u> , the kids are really like, this is a professional video, like, there into it <u>20</u>	<u>16</u>	Open ended video
M: ya		
R: when I make the videos, <u>its</u> not quite the same level of attention <u>21</u>	<u>21</u>	Attention
M: laugh		
R: or care, <u>22</u> so if you, if there is a question posed on the video and I pause it at that time or even the speaker in the video says	<u>22</u>	Meaningful
M: you, you would like, <u>lets</u> say almost with every video to have questions posed within the video at the crucial moment		
R: <u>ya</u> , and even pause <u>23</u> this video now and consider it for two minutes and a teacher can always choose not to do that, but <u>its</u> actually really nice to have such a deliberate instruction <u>24</u> and so you pause it and <u>its</u> like <u>its</u> not coming from me then, you have two minutes, <u>lets</u> go.	<u>23</u>	Segmentation
M: you see, I was wondering when I was watching that, like is, is it a case of, you didn't really use it as a hook video per say		
R: <u>its</u> true, I didn't		
M: you used it as a high quality video and the hook was kind of like, there was a competition and there was a prize		
R: <u>ya ya</u>		
M: I mean, I liked it because when they watched the last bit of the video and they say it spinning		
R: 'that's <u>coool!</u> impersonating students <u>25</u>	<u>25</u>	Situational interest
M: some of them said 'o that's cool', ok so it's a hook in that sense, but are you saying from a teaching perspective that you		

Figure 5.5: Screenshot of first cycle coding (manual) being conducted in Microsoft Word 2016. Coding is placed in red on the right with an associated number that links back to the text

5.14.1.7 Codebook

In tandem with first cycle coding, a codebook was maintained. Development of a structured codebook with increasing familiarisation is a core facet of the thematic analysis approach (Rohleder and Lyons 2014). A code book enables a researcher to code consistently (Gibbs 2008). This is advocated by numerous authors since the volume of codes can extrapolate quickly (Saldaña 2012, Fereday and Muir-Cochrane 2008, Gibbs 2008, Braun *et al.* 2014). A code book is an organised list of codes (Denzin and Lincoln 2008). This book contained every code developed, an example of when the code was applied and a descriptor of when to implement it. This is vital so that other researchers can analyse your interpretations and understand your analytical methods (Auerbach and Silverstein 2003). The compilation of codes has been constantly revised and retuned throughout analysis. Some codes have been combined to form one single code whereas other have been split up depending on the narrowness or broadness of descriptions (Saldaña 2012). The codebook was established and maintained in Microsoft Word 2016. An example of the codebook layout is demonstrated in Figure 5.6.

Chapter 5: Methodology

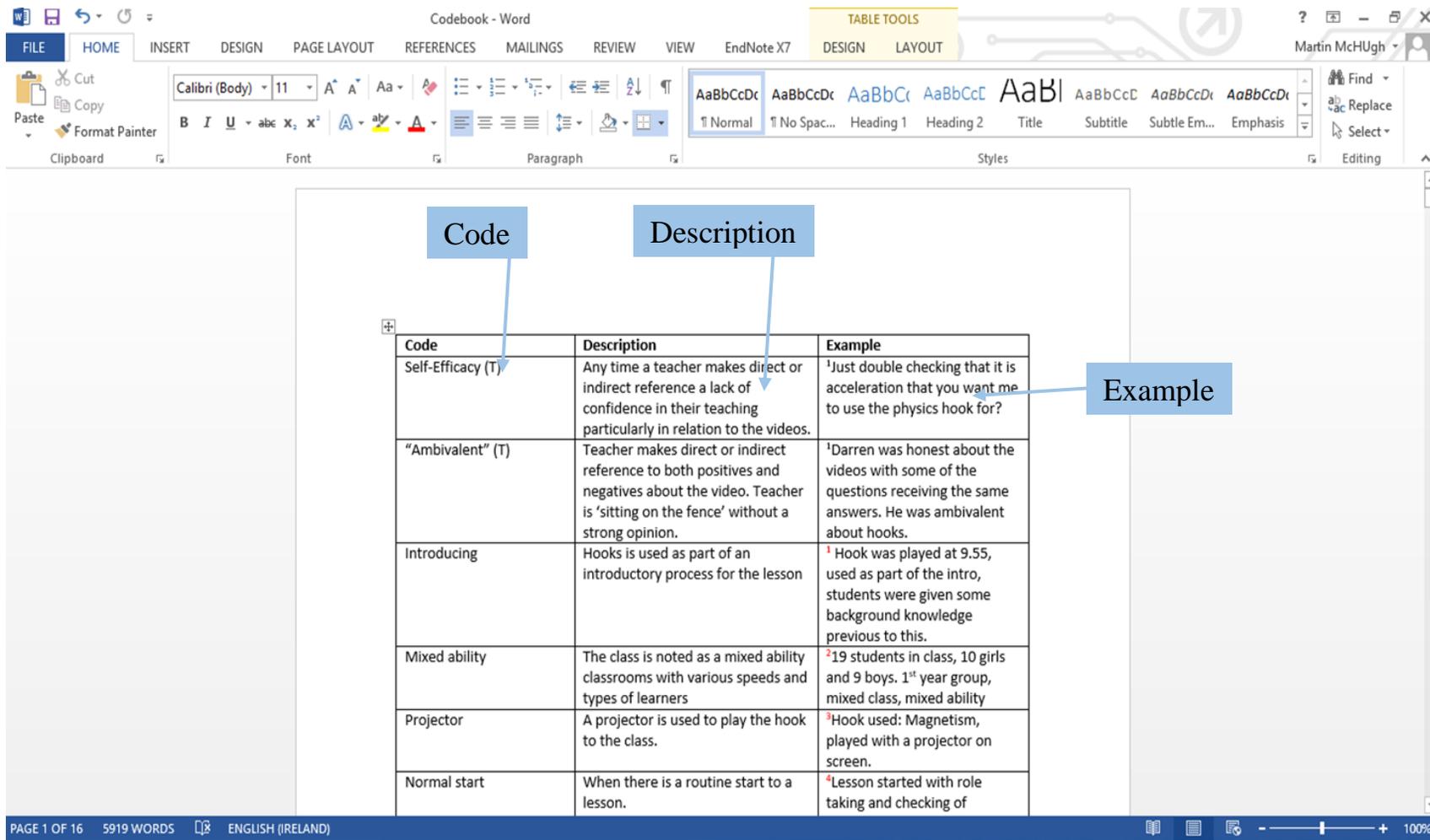


Figure 5.6: Screenshot of the codebook developed throughout first cycle manual coding and maintained throughout all phases of analysis. Each code receives an individual descriptor and an example from the data. 303 codes were developed, described and placed in the codebook

5.14.1.8 Second Cycle Coding

As noted in the recommendations above, second cycle coding, the next process of abstraction, was conducted in NVivo 10. NVivo is a qualitative analysis software tool for working on rich, text based data that require deep levels of understanding. The use of software is particularly beneficial for the manipulation, coalescing and tuning of categories (Richards 2002) in a way that is more methodical than manual methods (Bazeley and Jackson 2013). This involved code refinement and amalgamation of similar and removal of redundant codes to create sub-codes and categories, eventually leading to themes (Saldaña 2012, Malterud 2001). Contrasting codes may shed light on ‘rival’ patterns that require comparative analysis and refinement to discover the true implications of the data (Gall *et al.* 2007). This process is time consuming and resource intensive, but is a key element in being scientific and removing bias in qualitative research (Sofaer 2002). Categories, “must be exhaustive and mutually exclusive” (Graneheim and Lundman 2004, p.107). No data should fall in between categories or fit into multiple categories. All data should reside in its own particular scheme (Graneheim and Lundman 2004). Within NVivo, all codes and transcripts were revised and the researcher searched for patterns within the data (Figure 5.7) while grouping codes and sub-codes under parent ‘nodes’ in the software. NVivo also enabled the use of coding stripes (Figure 5.8). Coding stripes allow the researcher to visually assess the data that has been coded while also permitting the examination of areas in the transcript in which codes overlap. This provides for confirming and disconfirming analysis and evidence generation. Finally, the software allowed for the development of research annotations and link memos that could be attached to the transcripts (Figure 5.9). This allowed the researcher to develop and maintain new ideas while preserving the context of the data. A record of sub-codes, categories and themes developed are contained in appendix D.

Chapter 5: Methodology

The screenshot displays the NVivo 10 interface with the 'Nodes' list expanded. The 'Good classroom environment' node is highlighted in red, along with its sub-codes: 'Good discipline', 'Positive learning environment', 'Positive reinforcement', and 'Student Teacher Rapport'.

Name	Sources	References	Created On	Created By	Modified On	Modified By
Colloquial use of language	7	9	07/09/2015 10:58	MM	01/10/2015 12:12	MM
Design of hooks	12	103	25/08/2015 12:43	MM	14/10/2015 12:01	MM
Deviant example	2	2	01/10/2015 12:15	MM	01/10/2015 12:15	MM
Differentiated learning	3	5	01/09/2015 11:24	MM	07/09/2015 10:33	MM
Experiments in class	1	1	26/08/2015 12:39	MM	26/08/2015 12:53	MM
Future use of videos	6	6	31/08/2015 19:37	MM	01/10/2015 12:06	MM
Good classroom environment	7	17	25/08/2015 12:32	MM	26/08/2015 12:52	MM
Good discipline	1	1	26/08/2015 12:40	MM	26/08/2015 12:40	MM
Positive learning environment	3	3	25/08/2015 15:46	MM	26/08/2015 11:50	MM
Positive reinforcement	2	4	25/08/2015 15:35	MM	26/08/2015 11:50	MM
Student Teacher Rapport	6	7	25/08/2015 12:21	MM	31/08/2015 19:20	MM
Pedagogy used	20	113	25/08/2015 12:44	MM	26/08/2015 12:52	MM
Personal interest	7	18	25/08/2015 12:39	MM	14/10/2015 12:01	MM
Practicality	4	11	31/08/2015 19:13	MM	07/09/2015 12:13	MM
Pre hook method	11	48	25/08/2015 15:24	MM	26/08/2015 12:52	MM
Prior knowledge	13	21	01/09/2015 21:21	MM	14/10/2015 12:01	MM
Staging video	8	8	25/08/2015 13:06	MM	07/09/2015 10:56	MM
Student Impact	26	229	25/08/2015 12:45	MM	26/08/2015 12:52	MM
Students asking questions	2	2	30/08/2015 16:48	MM	01/09/2015 11:11	MM
Use video where it fits	5	10	31/08/2015 19:16	MM	07/09/2015 10:32	MM
Video Integration	4	8	01/09/2015 12:37	MM	14/10/2015 12:01	MM

Figure 5.7: Screenshot of NVivo 10 displaying the completed nodes list from secondary pattern coding. An expanded parent node is highlighted in red with its sub-codes

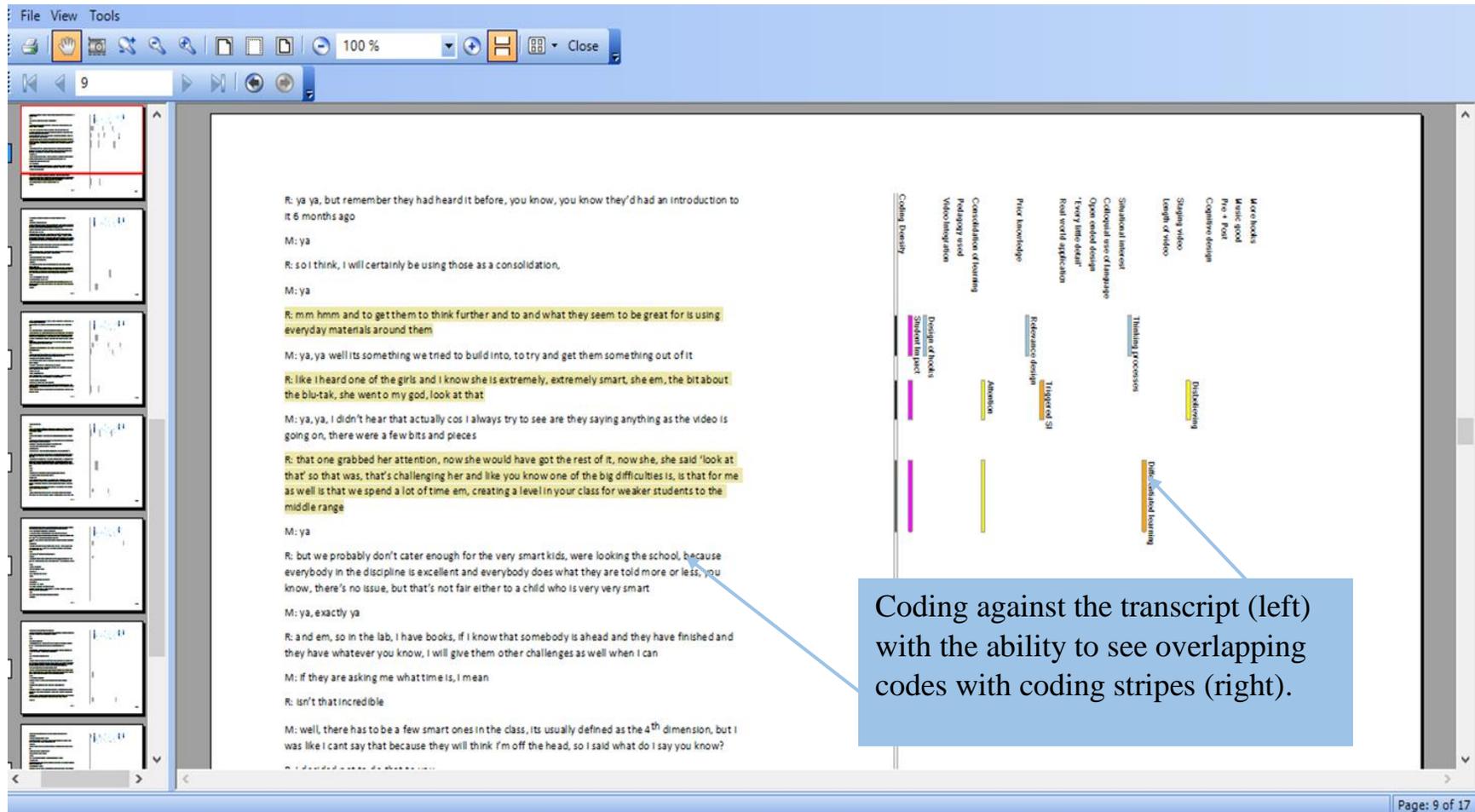


Figure 5.8: Screenshot of NVivo 10 with highlighted text and relevant coding stripes. It should be noted that second cycle coding is less dense than first cycle coding

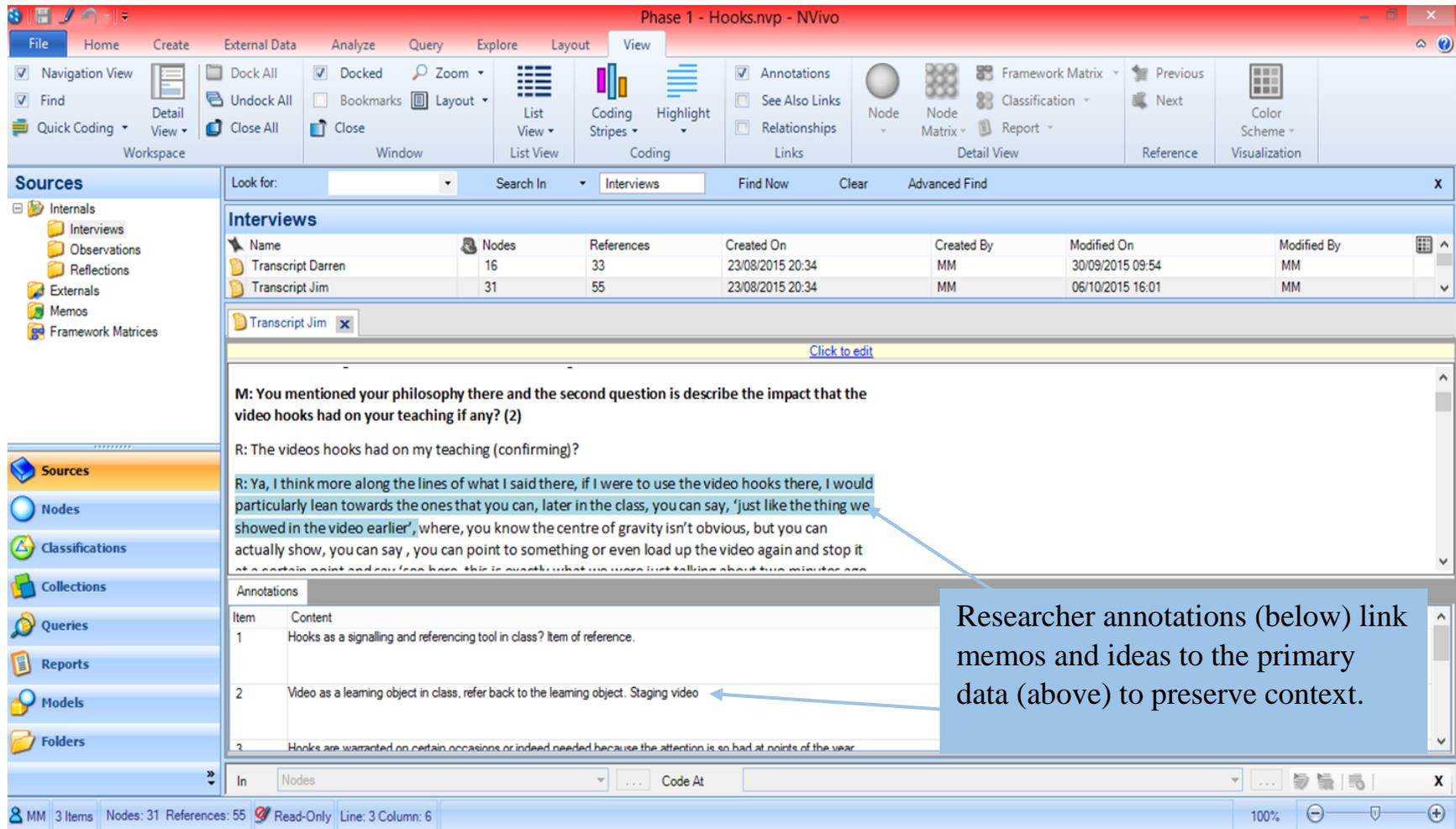


Figure 5.9: Screenshot of NVivo 10 demonstrating the use of the annotation feature to incorporate researcher thoughts and reflections throughout the text. Annotations are in the ‘Annotations’ box at the bottom of the screen with the pertinent text highlighted blue in the box above

5.14.1.9 Second Cycle Coding – Theme Development

At this point, all codes and segments are grouped together and themes have been unearthed through the coding regimen. Themes link multiple categories or sub categories and represent recurring regularities throughout the data (Graneheim and Lundman 2004). They attribute meaning to groups of codes or categories in a provisional manner. In practice, themes attribute clusters of meaning across the data set. Themes should not overlap, but should relate to each other (Braun *et al.* 2014). They are pieces of a puzzle and create a coherent image of the data. Themes must be revised and interconnections analysed. To aid in this process, hand drawn thematic maps were developed for each intervention cycle (Figure 5.10). This is a quality control phase in which themes are checked to see if they are an appropriate fit with and relevant to the data (Braun *et al.* 2014). In this process, themes may be tweaked, split or discarded. At this point, a researcher must look back at their research question and see if it has been effectively answered through theme development (Braun *et al.* 2014). Once this revision process is finalised, thematic maps can be developed that fully realise the findings of the data (Figure 5.11). They display the interplay and intersections between themes and provides an overall structure for the final analysis (Braun *et al.* 2014). The last step of in the progression involves generating a final report with explanatory and analytical findings extrapolated through examining the literature review and new literature (Elton-Chalcraft *et al.* 2008).

This marks the end of the data analysis process. An overview of the iterative analysis framework utilised in this research is presented in Table 5.3 below.

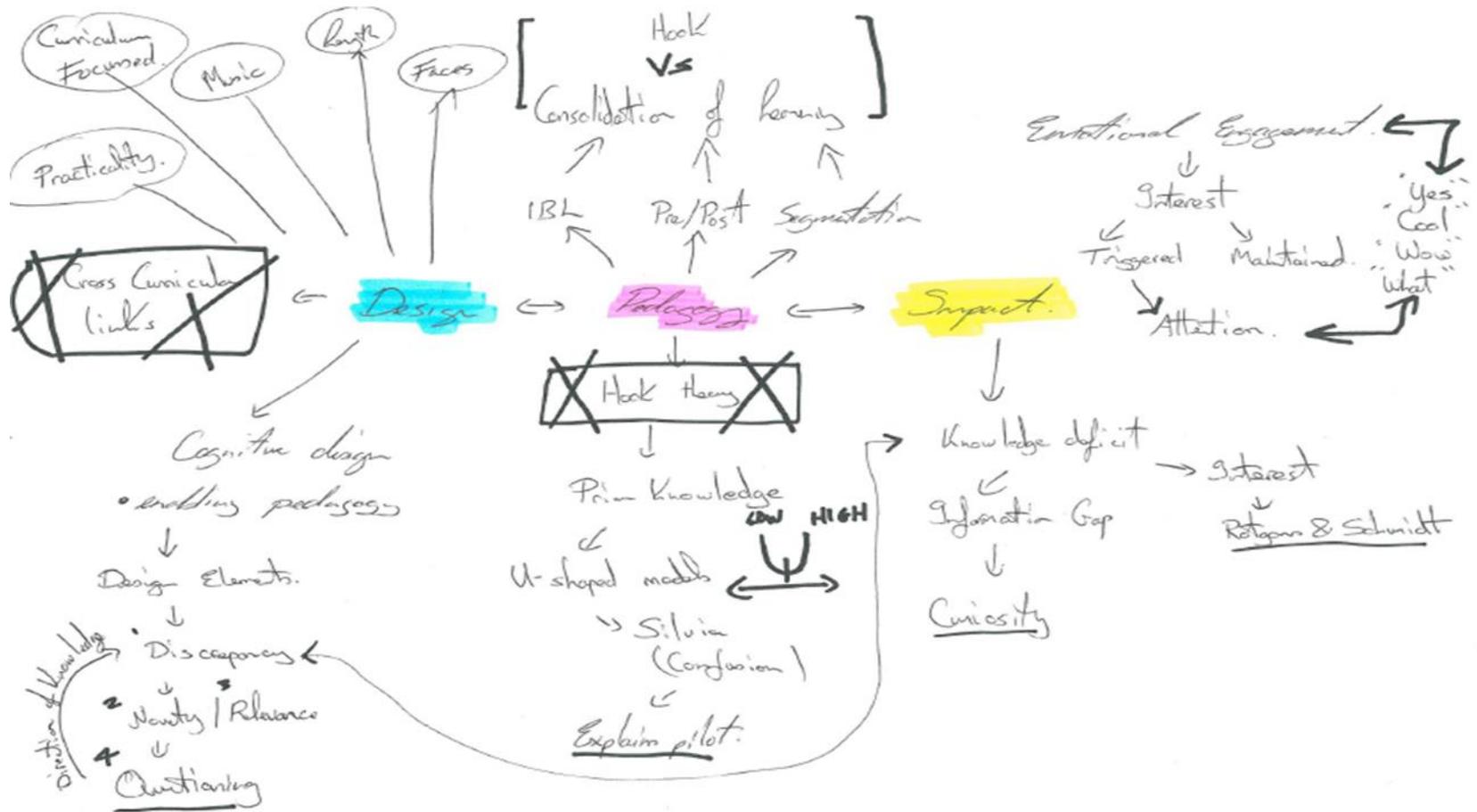


Figure 5.10: Example of a hand drawn thematic map development for phase 2. Initial models were hand drawn to encapsulate the researchers thinking processes as themes evolved and to determine relationships between factors

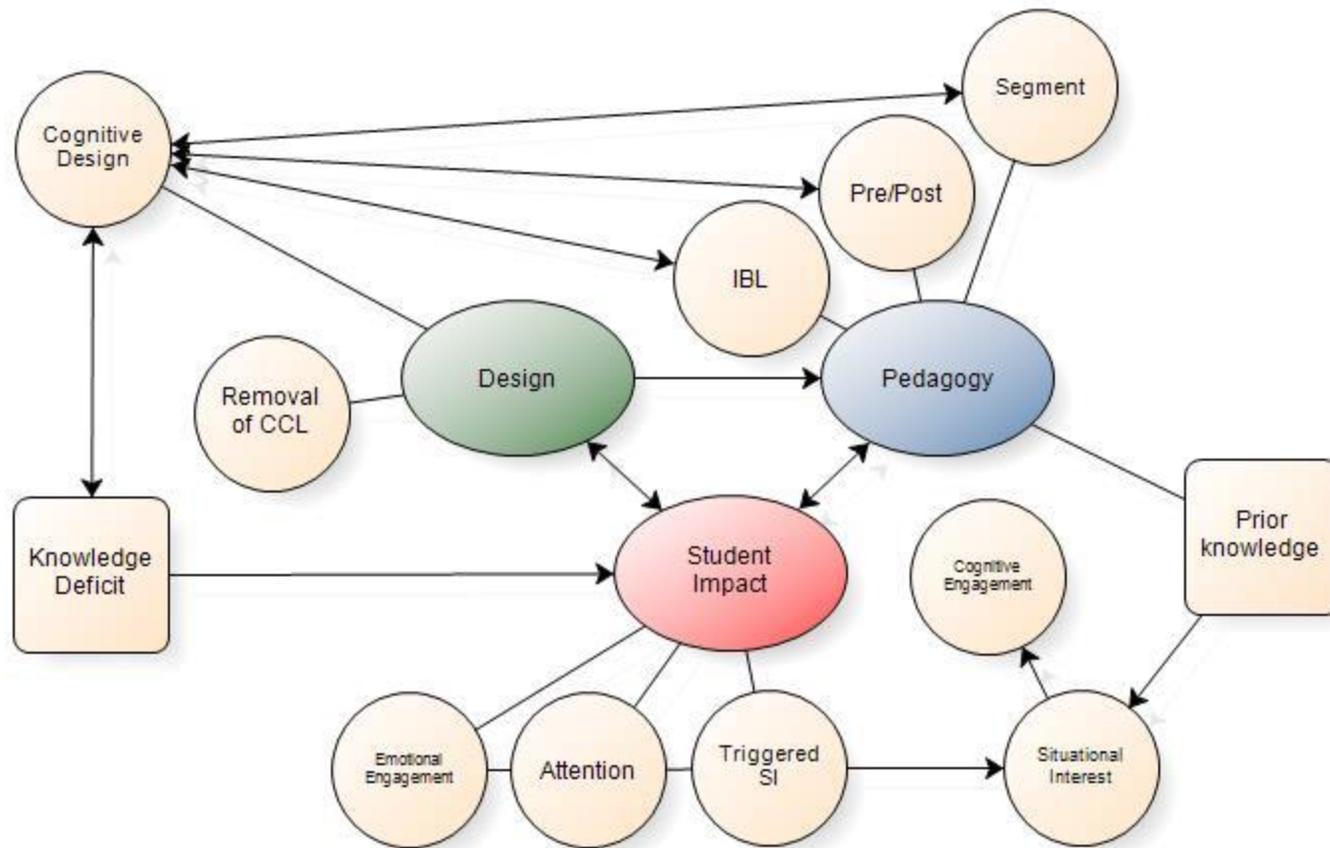


Figure 5.11: Finalised thematic map derived from iterative revisions for design cycle 2 in this study. It displays associative and direct relations between themes

Table 5.4: This is the iterative analysis framework that is derived mostly from thematic analysis methods, however, it has been supplemented with additional logical steps to ensure that rigour, validity and quality of assessment are more readily observable within this research project. Moreover, a more structured audit trail is developed with this type of analysis framework

Stages of Analysis	Authors	Description	Abstraction
1. Pre-coding	Gibbs (2008)	<p>1. Pre-codes are derived from research literature, previous studies and researcher hunches. A collection of concept-driven codes can be collected and applied as the key thematic ideas when they become apparent within the data.</p>	
2. Familiarisation	Braun <i>et al.</i> (2014), Petty <i>et al.</i> (2012b)	<p>2. The data is read on several occasions to gain a familiarity with entire texts.</p>	
3. Transcribing	Braun <i>et al.</i> (2014), Petty <i>et al.</i> (2012b)	<p>3. Transcribing is the first crucial step and there is potential for massive data loss or distortion from audio/visual accounts to written ones.</p>	
4. Analytical memos	Saldaña (2012)	<p>4. The researcher writes memos on sections of data to abstract more ideas and deepen analysis.</p>	
5. First cycle coding	Braun <i>et al.</i> (2014), Saldaña (2012)	<p>5. Elemental coding methods were utilised as the study has multiple types of data. A codebook was maintained. Coding was conducted manually in Word 2016.</p>	
6. Second cycle coding	Elton-Chalcraft <i>et al.</i> (2008), Saldaña (2012)	<p>6. Second cycle coding involves the development of categories and descriptive accounts in the search for meaning. Meanings are developed by merging, deleting and founding key codes, sub-codes and categories NVivo 10 was used during this stage.</p>	
7. Theme development	Braun <i>et al.</i> (2014)	<p>7. Thematic analysis is the search for themes that emerge in data to adequately describe a phenomenon. This is a form of pattern recognition within the data generally based on categories.</p>	
8. Theme refinement	Braun <i>et al.</i> (2014), Cohen <i>et al.</i> (2011)	<p>8. At this point a researcher, must look back at their research question and see if it has been effectively answered through theme development. The development of a thematic map, displays interplay and intersections between themes and provides an overall structure for the following analysis.</p>	
9. Final report	Braun <i>et al.</i> (2014)	<p>9. The final phase is producing the report. This is the final refinement in which the themes are describes through an analytical narrative interwoven with extant literature.</p>	

5.14.1.10 Quantitative Analysis of Qualitative Data

Although the data generated within this project is qualitative in nature, quantitative measures have been utilised in some instances to illuminate patterns and frequencies. This research examines complex interrelationships in situ, which often require a level of quantification to forward analysis (Abeyasekera 2002). Quantification of qualitative or word based data aligns with the coding processes employed as Bernard and Ryan (2009) state that qualitative data analysis reduces verbal data into measures of occurrence. The process of coding, fragments social encounters to reveal patterns and trends (Savenye and Robinson 1996). Therefore, quantitative analysis of large qualitative data sets can aid a researcher in determining meaningful themes (Abeyasekera 2002). Quantitative analysis is also useful in qualitative studies when there is repetition or common features in samples. Frequency is the main quantitative measure employed in qualitative studies (Abeyasekera 2002). Taking into account that comparisons can be made between teachers, especially within the upcoming design cycles and the large amount of survey data generated from students in design cycle 3, quantification in terms of frequency and percentages will further illuminate results in the following chapters.

Chapter 6: Design Cycle 1

6.1 Chapter Introduction

This chapter will discuss design cycle 1, the pilot phase in which the hook videos were initially implemented with two pre-service secondary science teachers. The chapter presents a structured narrative of how the physics video hook design and hook pedagogy, derived from theory was placed into the classroom context. This implementation process will be fully elaborated upon, followed by the resultant emergent themes and findings. The chapter ends with research informed changes leading toward design cycle 2. Evidence will be discussed with exemplars of data to illustrate the impact of the video hooks on classroom ecology. The discussion is initially framed in terms of the teacher participant approaches to integrating the video hooks into their classrooms lit ofwith concurrent analysis and overlap with the associated student impact and physics video hook design sensitivities.

6.2 Design Cycle 1: Implementation Strategy

6.2.1 Overview

This intervention and associated research methods have been developed to answer the primary and subsidiary research questions;

How can physics video hooks be designed and implemented to generate student attention, interest and engagement in physics?

a) Does teaching with video hooks have the potential to target junior science students' attention, interest and engagement in physics lessons?

(b) If so: what are the integral components of physics video hooks from both technological and pedagogical design perspectives that shape the development of student attention, interest and engagement?

In attempting to answer these questions, design cycle 1 acts as a 'proof of concept' in which the prototype design and conjectures grounded in the previous chapters are drawn together and placed in the complex context of the classroom (Barab 2006). As such, this pilot intervention takes all the pertinent design inputs and seeks to generate outputs. However, it should be noted that this pilot is dual purpose. Similar to more traditional research methods, the pilot is being utilised to refine data collection tools (Chenail 2011), an archetypal procedure to ensure quality in projected

studies (Cohen *et al.* 2011) and the smooth running of future iterations (Sampson 2004). In line with the iterative, qualitative approach, the pilot allows for the refinement of the semi-structured interview and observation tools. Moreover, such tools are mediated by the skill of the researcher, thus the pilot allows for practice and improvement (Bodgan and Biklen 2003, Elton-Chalcraft *et al.* 2008, Stake 2013, Van Teijlingen and Hundley 2002).

The following will illuminate the specific intervention strategy in light of pedagogical design and physics video hook design, the implementation strategy will culminate with a conjecture map (Sandoval 2014) characterising design cycle 1 prior to enactment.

6.2.2 Pedagogical Design

In term of pedagogical implementation of the physics video hooks, reference was made to all of relevant hook literature, the output of which determines that hooks should be utilised at the beginning of instruction. (Broggy *et al.* 2014, Bybee *et al.* 2006, Bybee 2009, Dittmar *et al.* 2014, Hunter 1994, Jewett Jr 2013, Keller 1987a, Lemov 2010, Schuck 1981). Therefore, this instructional method will be employed as the pedagogical accompaniment to the video hooks throughout design cycle 1. The advice, although simple will be the only instruction given to participants enacting the intervention. This will provide a frame of reference by which the pedagogical suitability of this method will be tested within the Irish junior science classroom.

6.2.3 Physics Video Hook Design

The physics video hook design refers to chapter 3 in which the process of design was illuminated. It encapsulates the core design elements and principles of the physics hook design, with reference to their derivation from the literature. The overarching design is situated in cognitive load theories and multimedia design principles. Under this umbrella, specific design elements of questioning, discrepancy, relevance and novelty are built into the hooks. This initial design represents an adaptable design framework that will be enacted in the classroom context along with the aforementioned pedagogical design. Together, they represent the foundation of design cycle 1. The aim of the combined theory is to augment attention, interest and engagement among science students. This will be fully delineated in the following sections.

6.2.4 Intervention Design

The bespoke proto-theory being implemented throughout this intervention design is completely grounded in the physics video hook design framework delineated in chapter 3 and the theoretical derivations in chapter 4. This represents an amalgamation of the pertinent literature and theory

regarding to hooks (Edelson 2002, Flynn *et al.* 2016). Therefore, this intervention begins with the goal of advancing and legitimising hook theory and practice by placing the synthesised concepts in the naturalistic context of the classroom. The proto-theory developed for the pilot phase is represented in Figure 6.1.

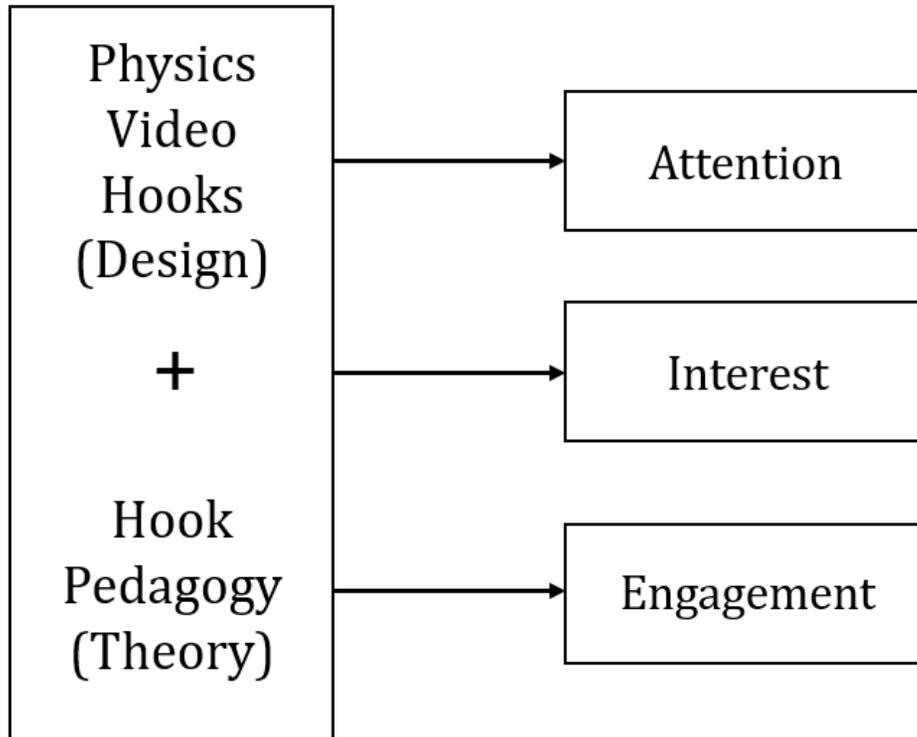


Figure 6.1: Diagrammatical representation of proto-theory derived from the literature being implemented in design cycle 1

As can be seen from the diagram, the main design sensitivities surround the utilisation of a hook based pedagogy, how this interacts with the physics video hook design and the predicted student impact of attention, interest and engagement. Thus, the affective and cognitive impact on the student body represents the projected outcome of the intervention during design cycle 1. This is illuminated using a conjecture map in the following section.

6.2.5 Conjecture Map

The conjecture map is a means of specifying the salient relationships in a design intervention or iteration (Figure 6.2). It sets out the specific speculative impact of a design pertaining to its function within a learning context (Sandoval 2014). As a whole, the figure below represents the current intervention and predicted paths based on the design artefact and theoretical derivations in

this study with the speculated outcomes of attention, interest and engagement. Within the diagram below, embodiment refers to the design artefact and conditions for enactment. Mediating processes include changes that should occur within the context, based on the interactions between the intervention and local players. Such mediating processes often inform methodological tools. Outcomes refer to the projected outputs from the intervention (Sandoval 2014).

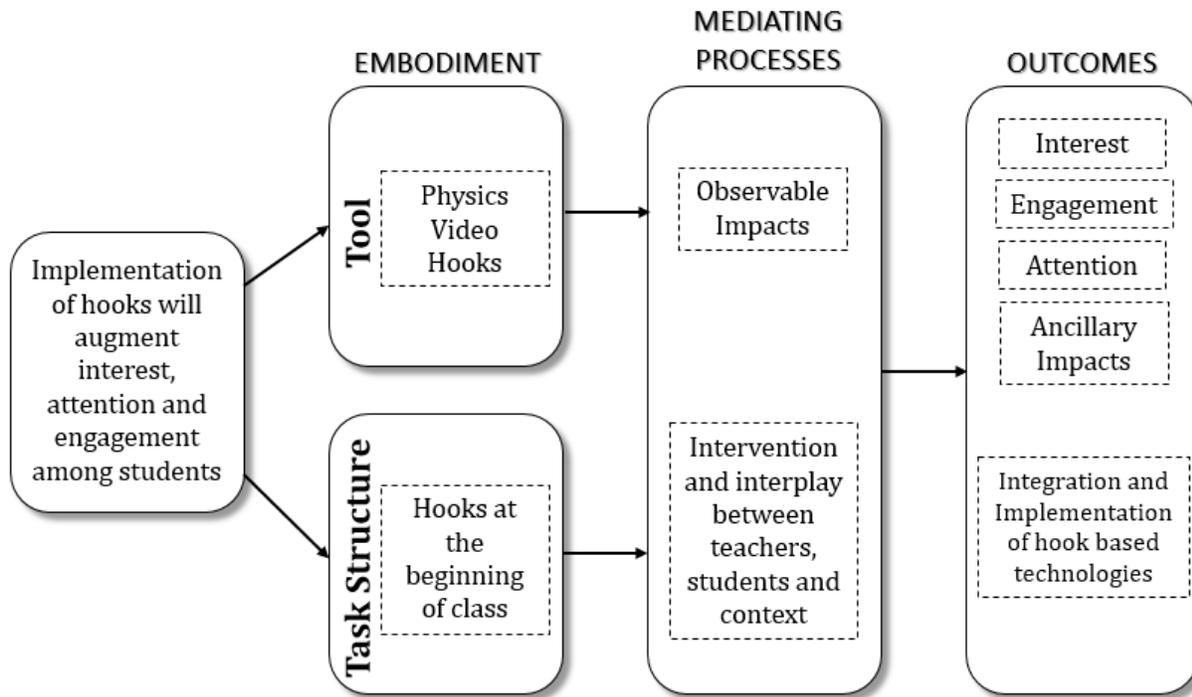


Figure 6.2: Conjecture map summarising the enactment of, and predictions in design cycle 1

6.2.6 Methodology

Having outlined the theoretical foundation and predictions for design cycle 1, a methodology is required to allow for both the enactment of the design and the generation of key data to advance all aspects of the intervention.

This research explores a relatively new area of study, physics video hooks, in considerable depth. It investigates how teachers implement such a resource in the Irish junior science classroom, how students react to this resource and what changes are required to its design. This is an initial, exploratory study intending to identify and explore phenomena discovered within a small sample (Kortland and Klaassen 2010), typical of design-based approaches (Bakker and van Eerde 2015).

With this remit, junior science teachers are required as participants to conduct the intervention. The researcher did not want to pilot the research with in service teachers as this may reduce the sample pool for further design cycles. Hence, the pilot looked to work with two pre-service science teachers from the 2014 Professional Masters in Education (PME) from the school of education in NUI Galway. This involved a brief meeting with the class to introduce the study and invite participation, followed by circulating an email that gave an outline of the study and invited volunteers from the class of 17 to respond (appendix B). Four teachers responded and two were chosen on the basis of proximity to the University. Although, the researcher acknowledges that due to the small scale nature of this pilot that there may be issues of generalisability, in terms of the data; however, coupled with the goal of advancing the physics hook intervention, this pilot is being utilised to test data collection methods and instruments (Gall *et al.* 2007). Based on the arguments above, it is position that the methodology in this design cycle is just and should afford ample opportunity to legitimate the research in a balanced fashion.

The teacher participants were asked to review all the hooks, and perform an intervention with one hook each in their respective classes. The intervention takes place in the classroom in order to be as naturalistic and as close to real life as possible (Liu *et al.* 2009). An intervention approach is being used as the research wants to identify successful and unsuccessful components (Spencer and Britain 2003) of the hook design and associated teaching methods.

The three data collection tools employed in this pilot include observations, interviews and researcher reflections to lend further credence to findings. The specific strategy is determined by what method will yield the best information at this stage of research. The methods were selected to allow for the generation of valid and rigorous data through triangulation.

This design cycle works more so with teachers than students. This is an explicit choice, as Szeto and Cheng (2014) and Bitner and Bitner (2002) state that teacher approval and cooperation are fundamental to the implementation of any classroom based technology. Furthermore, Bingimlas (2009) identifies a number of barriers to the smooth integration of ICT into schools, the first are teacher level barriers. Hence, this phase and its accompanying methodology aim to overcome the teacher barriers by working mainly with teacher participants and students to a lesser degree.

6.2.7 Data Analysis

Data analysis throughout design cycle 1 follows the protocol set out in chapter 5. Items for analysis included systematic observation reports, semi-structured interviews and researcher reflections written directly after the observations and interviews. All of the data collected was coded using manual methods for first cycle coding and NVivo data analysis software for second cycle coding (appendix D) (Saldaña 2012). The hybrid thematic analysis (Clarke and Braun 2013, Saldaña 2012) was utilised to develop a thematic map for design cycle 1 (figure 6.3). It summarises the broad emergent findings that developed from the data. Within the map, the focal points are design, impact (student) and pedagogy with associated offshoots identified in line with the research objectives and findings. Arrows and associations display how themes interacted with one another throughout the phase. The thematic map is derived from evidence within coded data. It informs the interplay between thematic and theoretical considerations throughout the pilot phase of research. The themes derived from thematic analysis and the entire coding process are discussed within the findings section and elaborated upon and explained with pertinent literature. The map provides an overview of the findings section, which will firstly delineate the pedagogy of the intervention and develop the discussion further into other thematic areas of significance.

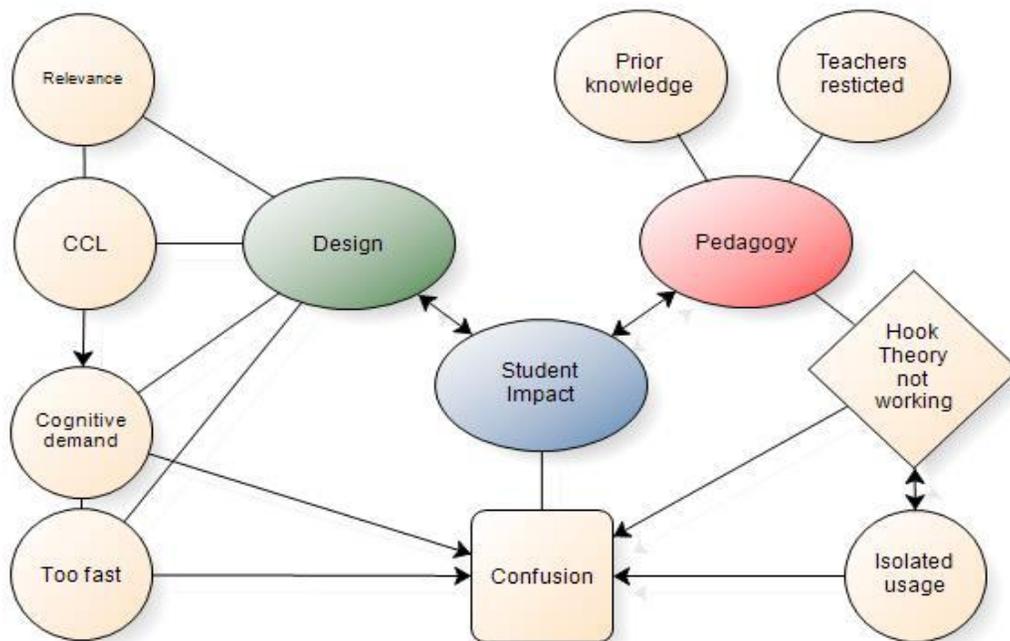


Figure 6.3: Thematic map derived from data in design cycle 1

6.3 Design Cycle 1: Findings

Findings from the interviews, observations and reflections derived from the pilot intervention are presented here. Findings are represented as themes abstracted during data analysis. Firstly, the pedagogy utilised by the participants will be discussed in light of their interaction with the theoretically based instructional goals of hooks. Secondly, the student impact will be discussed with regard to its manifestation in accordance with the pedagogy and the physics video hook design. Finally, the video hook design will be illuminated with reference to teacher participant's perceptions. As a caveat before exploration of the pilot findings, it should be noted that participants were asked to review the entire suite of eleven hook videos and determine their viewpoints based on this and the intervention. However, in both interventions the same hook, magnetism, was implemented. Hence, the data derived somewhat reflects the utilisation of the same hook within each class.

6.3.1 Off the Hook? Introducing Technology to Pedagogy

Situated and emergent within the data for design cycle 1 is the misalignment between the theoretical derivations of hooking and its pedagogical implementation in the classroom. As fully described in Chapter 4, hooks represent a pedagogical method utilised at the beginning of instruction (Jewett Jr 2013, Lemov 2010). With this theoretical consideration, both teachers were asked to employ a hook in their respective interventions in an introductory manner. Given this, Darren, one of the teacher participants, delivered a few lines of background to the content and then played the video hook. In Jim's class, he asked the students;

Jim: "*Guess what the new topic is?*" (Observation ROJ14)

He then proceeded to play the video and the students had to answer the question. Both teacher participants utilised the hook to introduce a new topic and both used it at the beginning of the lesson after routine roll calls and homework checks. After employing the hook as their respective introductions, neither teacher referred to the hook again during the lesson. Given this, the video hook represented an isolated event (Shephard 2003) within the wider learning ecology and was not embedded into the overall architecture of the lesson. This was noted throughout observations;

"Teacher using the hook as something that is very independent in class rather than something that one would work with, it is an isolated event." (Observation ROD14)

Indeed, the theme of isolated pedagogy was evident in the interviews. Both participants found the hook instructional strategy limiting with specific reference to its use at the start of lesson. Jim continually noted throughout his interview how he would have attempted to refer back to the hook, however, this was not in the remit of the pilot. He expressed the following;

Jim: *“I like that idea of a hook ... you can refer back to the hook and see ... the thing that we showed earlier ... and you can link your teaching back to the hook.”* (Interview IJ14)

When asked to expand on this idea, Jim responded;

Jim: *“This is what I mean about being able to refer back to the hook, you could even go back and reshow the video and say remember what I am talking about now.”* (Interview IJ14)

The quote demonstrates how the teacher has a different ideology pertaining to how he defines a hook and would like to refer back to the hook, perhaps replay the hook, but did not enact the hook in this fashion due to the restrictions of the theoretical impart of the current design cycle. Hence, the teacher is reflecting on what he wanted to do in class and where he observed a niche for the technology in his classroom ecosystem. This participant referenced this idea of referring back to the hook on seven different occasions during the interview, which lends credibility to the argument that he felt pedagogically restricted by the hook teaching method. Darren added to this debate and elucidated how students needed more background to the video, something he identified, but only enacted to a limited degree during the intervention.

Darren: *“I think you need to give them (students) some background to it, whether it’s the teacher, maybe if the teacher explained the thing fully beforehand, it might work at the start.”* (Interview ID14)

A strong sentiment in the quote from Darren is the work “need”, that is, the intervention needed something different from what was initially proposed. Indeed, throughout the entirety of the intervention process, the teacher participants were starting to reflect and realise that the value of video resides in its implementation. This is in agreement with literature on video that posits that video should be traversed in an interactive manner (Zhang *et al.* 2006), while being integrated into learning tasks (Karppinen 2005). However, the enactment of the videos under the guise of hooks,

did not afford for pedagogical choreography, something that, based on findings would have synergised more so with the teacher participants. In light of the actualisation of the intervention, both participants kept to the script and employed the hooks based on the advice given. The hook was designed and thusly treated as a singularity that should operate in and of itself. However, results the emergent themes point to a schism between context and design, one that teachers in this phase attempted to mediate, but were restricted. According to Sharma and Hannafin (2007) technology in an educational context has to be facilitated by interactions between a novice and an expert, often in a bespoke manner per the complexity of the classroom. A balanced system is required so both the teacher and student can progress. As such, the argument can be constructed that the instructional advice given, along with the design, lacked a structure or scaffolding that was in line with the teachers' pedagogical beliefs or the needs of the classroom (Davis and Miyake 2004). Further justification for this is how one might conceptualise a hook, Darren notes;

Darren: *“The majority of teachers when they hear hook would automatically presume it has to be first thing.”* (Interview ID14).

Hence, the word ‘hook’ as a colloquialism, potentially lends to a tokenistic output. A gimmick that represents an island at the start of the lesson rather than a bridge to the rest of the class (Mitchell 1993). Significantly, all of the data collected indicated that the use of the physics video hooks was restricting when used at the start of the lesson. It seems the video hooks did not ‘fit’ the classroom context (Bravo *et al.* 2011). Mishra *et al.* (2009) argues that utilising technologies in a way that they are instructionally effective requires specific knowledge of how the technology can be applied to pedagogy, as educational technology exists in the interplay between technology knowledge, content knowledge and pedagogical knowledge. It can be delineated from the data that the specific knowledge and advice given to the teachers was ineffective, thusly, the interplay between the technology and pedagogy was limited.

Given the results, the impact of the hooks on the student body reflected its isolated implementation. This will be explored in the following writing.

6.3.2 Sling Your Hook: Confusion among the Digital Residents

As described by the teacher participants, the implementation of the physics video hooks into their respective lessons was a procedural traversal, lending to the possibility that the resource was not actualised in the most suitable manner. Indeed, compounding this issue are the students' reaction

to the hook. Based on observations and teacher interviews, the broadly defined reaction for the majority of students was one of confusion. The subtler complexities of the student response to the hook will be articulated in the following writing.

The initial reaction to the video hook in class was one of excitement. Students did not seem to care about content or duration since just the mention of the word ‘video’ enticed certain students to comment ‘yay’ and ‘yes’ (Gilbert 2005). Students looked at each other in a confirming manner when making these statements and the excitement built as the lights were turned off and the video was being loaded. This is akin Berk’s (2009) description of how video should be used in an impactful manner. The author states that provocative video clips can serve as a “fireball stimulus package for a new topic” (Berk 2009, p. 11). In light of this, the design of the hooks in a digital video format was seemingly a good choice as this initial reaction was a positive affective response. Further resonating with the initial hook design (Chapter 3), the student response could be due to their experience and familiarity with digital video. It is positioned that our target audience are digital residents (Connaway *et al.* 2011, White and Le Cornu 2011). Given this, the students awareness of digital media may have been the basis behind their initial attentive and enthusiastic response.

Based on arguments put forward by Linnenbrink-Garcia *et al.* (2010), the initial attention observed was akin to a triggered instance situational interest. The instance in which the hook was played was the first time in class when all students were quiet. This phenomenon, along with positive body language such as sitting up in their seats to see the screen, represented an obvious upward shift in attention levels (Tsai *et al.* 2008). Triggered facets of interest, as described by Mitchell (1993), appear due to a change of pace that is perceived either in a sensory or cognitive manner. The initiation of the video in class signified a substantial change of pace. Hence, the hook had a positive start, however, as the video progressed, students began to disengage. Schraw and Lehman (2001) argue that interest can fade as rapidly as it appears. Grounded in the observations and researcher reflections, the students paid attention and were interested to the first half of the video. However, approximately during the middle of the video, the attention levels significantly dropped.

“Students seemed excited before, but the video lost their attention quickly.” (Reflection ORJ15)

Further, Darren had also picked up on this in class;

Darren: *“It definitely had their attention, now how much they engaged with it is something that would need to be looked at...”* (Interview ID14)

The reaction, initially, was one of attention and interest but the students assessed the video extremely quickly and eventually the majority of students observed disengaged. Both teachers described how students simply forgot the hook and moved on very quickly in class.

Jim: *“Then with regard to how the material, how the hook material suited them, that class tended to take that hook as kind of as something I showed and then that was it, forget it and then move on.”* (Interview IJ14)

Darren: *“I think with that particular hook, they probably moved on a lot quicker...”* (Interview ID14)

Since students were paying attention for the beginning of the video and then it started to fade, this lends weight to the previous argument that the hook acted similar to a ‘gimmick’ in class as it failed to maintain interest over time (Mitchell 1993). Indeed, the video hook, as a standalone event at the beginning of instruction did not provide for a longer-term engagement predicated on the initial design. Yet, emergent within the data, not only were students disengaged by the end of the video, they were confused. Some students looked at each other in a confirming manner and asked “What was that?” (Reflection ORJ14). Jim stated;

Jim: *Now they started saying, ‘what’s the point in all this?’ and I had to explain it to them.”* (Interview IJ14)

In this instance the teacher recognises the misalignment between the predicted hook output and the actualities of the classroom context, thus he modified his teaching to quell the confusion in class. In attempting to explain the confusion, one teacher participant indicated that students did not have the correct level of prior knowledge to comprehend the hook. The class was made up of twelve-year-old students and they had little to no knowledge regarding the hook content barring their intuitive knowledge. This was noted in Darren’s interview;

Darren: *“...I think you need to give them some background to it, whether it’s the teacher, maybe if the teacher explained the thing fully beforehand, it might work at the start [...] there are some topics,*

like, density and that, they may have some idea from the primary school curriculum whereas others they mightn't." (Interview ID14)

The quote illuminates a situation in which this teacher is trying to explain why the impact of the hooks declined, and presents the idea of the class not having enough background knowledge of the video content. This lends credence to the previous argument of teachers feeling restricted by having to use the hook at the start of the class. Darren recognises the need for background knowledge and more explanations to enable the video to be more effective as a hook. The theoretical impact of utilising the hook at the start of class may have been the limiting factor leading to the student reaction. If prior knowledge is the key to understanding the video and potentially creating a 'hook' reaction, then the instructional strategy has to be overhauled in the next phase of research. In this cycle, the hook was isolated within the wider pedagogy and students not only disengaged (Ainley and Ainley 2011), but became confused.

However, Jim had another explanation for the students' confusion. He postulated that;

Jim: *"The negative and its nothing that could be controlled, is that it's not specifically tailored for that age group. I would say its tailored for another age group for them to fully grasp."* (Interview IJ14)

Jim: *"I think with second and third years they might engage with it a little bit more and look at it compared to what the first-year class did."* (Interview IJ14)

Jim's quotes illuminate a situation in which the students are too young to fully grasp the content of the videos and this accounts for their reaction in class. This stance suggests that the hook design was potentially too complex for a first-year class (twelve-year olds) and this is why the students became confused. However, the argument can also be made that the quotes describe a scenario in which the videos can be used as hooks with older classes, due to their higher level of inherent scientific background knowledge. To examine this juxtaposition further, and determine if prior knowledge or the video hook design were attributable to the students' reaction in class, the design of the video hooks, supported by research data, will be elucidated presently.

6.3.3 Hook Again: Uncertainty Pertaining to the Physics Video Hook Design

The following will delineate the findings pertaining to the video hook design as reflected by the naturalistic classroom context. In the previous section, it was outlined that the hook design may have been pitched at too high an academic level for students to fully conceptualise. It should be

noted that the explicit design of the hooks does not aim to work with students' intuitive knowledge, the content is specific, situational and syllabus centred. Its goal is to develop situational interest in science relevant to the curriculum. A salient design feature, it may be the rationale behind the student reaction along with the isolated implementation. Henceforth, this section will elaborate on the teacher participant's opinions pertaining to the video hook design artefact. As noted previously, teachers were asked to review all the hook videos. However, in this section in particular, the teacher's opinions of how the hook design was actualised in class is heavily based on the magnetism hook.

As referenced by the previous section, the two teachers reported that overall the students found the hooks to be confusing. One expression that was continually repeated was 'over their heads'. A statement that implies the video hook was too challenging for students to comprehend. When discussing this with Darren, he pointed to the cross curricular links within the magnetism video as one of the main sources of confusion. Underscored in Chapter 3, the cross curricular links were part of an overarching relevance strategy embedded into the hooks. The idea was that expanding into other subject areas would make the content more relatable and promote a wider area of interest than the topic being taught (Oon and Subramaniam 2011). The video was a combination of magnetism and speed. Darren notes explicitly how the amalgamation was ineffective;

Darren: *"I think it might have been a bit too far for them, but maybe that was because I was doing speed, velocity and acceleration and it (the video) was magnetism"*. (Interview ID14)

Darren suggests that the fact he was focusing on the speed aspect of the video, while the overarching theme is magnetism was the source of confusion and students could not connect the topics in their minds. As evidenced, the argument can be made that in this instance, the teacher is questioning the structure of the video. As Miller and Zhou (2007) note, the meaning of a video must be clear to an instructor. With the magnetism hook, the teacher is questioning the meaning from both a design and pedagogical perspective.

However, when questioning Jim about the hook design, he focused on the relevance of the magnetism video. When analysing this quandary, Jim indicated that this is a twofold problem. The video needed to be relevant or important to the students' personal lives and experiences. Moreover,

the hook needed to use more relevant objects and everyday materials/examples. The hook shown to students displayed a ‘magnet gun’ using neodymium magnets and ball bearings rolling across a table. Jim argues that the content is not an everyday example, relevant to the students’ lives;

Jim: *“Why do we need to know this (impersonating students)?’ Now, it sounds a bit silly to show them some weird hook that’s a bit bizarre like a magnetic rifle or whatever, that they’re not gonna use this everyday, it’s not an everyday case.”* (Interview IJ14)

The Welcome Trust (2011) articulated that levels of student engagement were correlated to the transferability of learning to the ‘real world’, something that Jim obviously felt was lacking in the hook as he continued;

Jim: *“I keep referring to magnetism because it’s the one we did, you know magnetic fields and stuff and they’re (students) kinda sitting there going ‘you know who cares’ and even if you can say, well remember the thing with the magnet rifle, it’s almost like they go ‘o, there’s a use’, ok it’s not an everyday use...”* (Interview IJ14)

The argument presented outlines that perhaps the lack of relevance within the hook as perceived by Jim, was the justification behind the students’ lack of interest and engagement with the hook and the source of ‘who cares?’ attitudes.

The above opinions must be acknowledged, however, they must also be framed by the fact that both teachers, when asked, recommended no changes to the video hook design. Their opinions in general can be described as ambivalent as they were positive about the format and quality of the videos. Their major concerns, although divergent, surrounded the academic level of the videos. Both will be taken into consideration as the project moves onto the next phase of research. In doing this, the data derived from design cycle 1 will inform the intervention in design cycle 2. Such modifications will be presently explored.

6.4 Changes and Modifications toward Design Cycle 2

The integration of the video hook technology into the complex environment of the science classroom lead to a myriad of changes within that setting. Similar to a ‘domino effect’, the multifaceted real world context, already in flux, underwent alterations (Amiel and Reeves 2008). This process unearthed the detachment between theory and practice and the pilot revealed this at an early stage of research. Within an iteration, major aspects of an innovation’s design

“defenestrated” and not act in a way that was predicted (Dede 2005, p. 6), a core attribute of design-based research (Hoadley 2004). This allows for self-corrective research to adapt and alter designs for the next phase and assure a closer line between theory and technological innovation (Wang and Hannafin 2005).

Moving forward onto design cycle 2, all the research evidence must be compiled and a plan of action devised. The key findings that potentially require revision prior to the second iteration of design from this pilot are summarised thusly.

Based on the data it was decided that the theoretical foundation of using a hook at the start of a lesson was ineffective in this instance, with the student impact being that of confusion and both teacher participants feeling restricted with this type of instruction. Therefore, pedagogically, changes will be implemented in design cycle 2. However, there was not enough evidence to suggest that prior knowledge should be a fundamental design sensitivity of hook implementation and instruction within the next design phase. Moreover, there was not enough evidence to suggest that the hook design required an overhaul to remove the cross curricular links or enhance the relevance strategy at this time, especially since both participants did not request design changes, but did intimate the restrictions the instructional strategy imposed. Yet, the pilot has alerted the researcher to both prior knowledge, cross curricular links and relevance as potential emergent design sensitivities and in lieu of intervention modifications, they will be areas of particular examination in the next phase. This will enable the further assessment of emergent design sensitivities and also allow for the potential design flaws flagged in design cycle 1 to be remedied by other, more appropriate instructional methods so that design and pedagogy can operate in tandem as opposed to the disjointed marriage described in this pilot. In essence, more data is required during the next design intervention. As a result, the following cycle, design cycle 2, will conduct more interventions and with more teachers. Design cycle 2, or the mainstreaming phase will expand on the work of the former phase by promoting successful and promising components of design and theory (Long and Hall 2015). All the changes mentioned above, along with changes to data collection tools and the overall methodology will be fully defined in the following sections.

6.4.1 Physics Video Hook Design Modifications

In terms of the hook design, teacher participants in the pilot phase were encouraged to assess all of the videos, not just the one they used in their respective interventions. With this data, no

modifications were made to the physics videos hook design as when questioned, the participants were ambivalent in their opinions. They recommended no significant changes in terms of content or redesign as they found it hard to judge the hooks in a fair and concise manner due to it not being effectively integrated into their respective classes. The main concerns relayed in terms of design was that the video content may have been too challenging or abstract to be classically labelled a 'hook'. That is, potentially the hook content does not interact with the students' intuitive knowledge, rather, per the initial design, it interacts with subject specific interest based on physics curricula content. However, when the hook was used in isolation, the students could not cognitively negotiate the videos. Dual explanations were presented in terms of design, with one teacher focusing on the cross curricular links embedded within the videos, and the other on the relevance of the content. Coupled, teachers posited that these aspects of the design may have been more of a hindrance than a help when it came to student understanding. However, it could not be discerned with confidence, if aspects of the video hooks design required modification at this stage. Therefore, the decision was made to maintain the videos in their current state and seek further qualitative feedback on these areas in design cycle 2. As a result, both the relevance and cross curricular link strategies will be key areas of focus in the next iteration, with specific questions pertaining to these areas being added to the semi-structured interview. This will be further elaborated upon in section 6.4.3 *Methodological Design Modifications*.

6.4.2 Pedagogical Design Modifications

The main finding from this design cycle, as suggested by the teacher participants, was that the hook teaching methodology they were asked to conduct was too restrictive. Additionally, the physics video hook design was too high an academic level to be utilised as a hook. As previously noted, the hook teaching method posits that a hook should be used at the start of class to initially garner students' interest (Lemov 2010). The benefit of which lies in behavioural and academic improvements throughout the rest of class and potentially beyond (Jewett Jr 2013). However, when the video hooks were used at the start of instruction, the students' interest was triggered initially as they payed increased attention, but it did not last as anticipated. Students found a disconnect approximately half way through the video, leading to confusion. During these moments, it was clearly observed that the video hook did not make any sense to many of the students. Some of the students were confused by the content and from a cognitive perspective could not understand the scientific phenomena in the video hook. Hence, the data revealed that there was no long-term

increase in interest or engagement in the content. The confusion was also noted by the teachers, who moved on with the lesson and clarified the misunderstanding in the rest of their teaching.

In terms of pedagogy, the hooks were an isolated event in the teaching and learning ecology. Their design was such, that the videos were presented to the teacher as an all-encompassing hooking strategy and all the teacher had to do was introduce the video and the topic, then press play. This was not the case as the hooks acted more in tune with what Mitchell (1993) notes as gimmicks that may catch, but not hold interest. Grounded in theory, simply utilising the video at the start of class did not provide a platform for the integration of the hooking mechanisms embedded within the video technology into the classroom. Liu *et al.* (2009) talk to the need for research in areas to support active and adequate use of educational technology in the classroom. Technology in class should have a highly demonstrable purpose (Bishop and Denley 2007). Simply placing various technologies into classrooms does not guarantee success. The classroom is a fluid ecology and the video hooks represent one component of the complexity of a classroom system. Learning outcomes from video depend on how it is used and its integration into other learning tasks (Karppinen 2005). In addition, it is thought that video lacks a key component of interactivity in order to truly have a positive impact on learning experiences (Karppinen 2005, Zhang *et al.* 2006). Traditionally, in video studies, learners must pay attention in a sequential and linear manner while pedagogical approaches that are focused on conveying fixed bodies of information have been criticised as learners are not proactive. Within the pilot phase, students were passive participants as they observed the video. The hooks were treated as a procedural resource, but video, as an educational tool should be traversed in a number of ways (Boyle 1997). The pilot highlighted a conflict between theoretical positions of the pedagogy associated with hooks and that of video. Thus, intrinsic to the hook design is a theoretical and ideological incongruity which the next phase of iterations in design cycle 2 aims to ameliorate. Lending credence to the above argument is that one of the teachers noted the role that prior knowledge could play in aiding students to fully conceptualise the videos. He positioned background knowledge as a key in student understanding. Given the above opinions, the following pedagogical modifications should allow for teachers to employ the video hooks in an unrestricted manner, based on their beliefs, experiences and classrooms. This will enable prior knowledge, along with other emergent design sensitivities to be compounded or alleviated through further examination.

The major design change for pedagogy in phase 2 is that teachers are asked to develop and employ their own pedagogical strategies to use in tandem with the video hooks. In the pilot phase, teachers were restricted by the pedagogy. To address this, an open pedagogy is now considered for design cycle 2. Teachers are asked to integrate the video hook, however they deem appropriate pedagogically, based on their experience and their class. The goal of the hook is still to augment attention, interest and engagement, however, teachers may utilise the video in multiple ways, according to their own teaching style and learner needs, providing incremental opportunities for learning. Therefore, the video hook may be used for dual purposes in class. The pilot took a theoretical position in terms of pedagogy and imparted that upon the participants' classrooms. Conversely, phase 2 will take practical teacher based orientation so that pedagogical methodologies instigated by practitioners can be identified through data collection and expanded upon with pertinent theory and literature. This is in line with DBR methods in which the practitioner perspective is valued in marrying theory and practice to inform design sensitivities (Barab 2006). This approach allows the research to remain practical and keep the instructional requirements of teachers a priority (Liu *et al.* 2009). The instructional requirements of teachers were not considered to such an extent in the pilot phase, but are a vital component of the design cycle 2. Taking this approach, however, requires largescale methodological alterations that will be discussed presently.

6.4.3 Methodological Design Modifications

The pilot phase took the form of a classroom based intervention and was deployed with a purposive sample of two pre-service science teachers. The participants were asked to conduct one physics video hook intervention each. Specific timings, directions and supporting documentation was provided with the stipulation that the hooks had to be used at the start of their respective lessons based on hook theory (Lemov 2010). Interviews were conducted with the participants upon completion of the intervention. Systematic non-participant researcher observations followed a set schedule and were conducted in class when the hook was used. Interviews were conducted and observation reflections were written by the researcher to lend further credence to findings.

Design cycle 2 is informed by and advances the pilot phase by expanding on the intervention based methodological design. Design cycle 2 takes the form of a qualitative intervention in which three interventions will take place in every teacher's classroom as opposed to one previously. Teachers will be asked to use a minimum of three physics hook in their junior

science classes over a period of four months from the suite of eleven videos. During this phase, ten secondary science teacher participants from across Ireland will be recruited for the study using a purposive sampling frame. Ten teachers from a variety of classrooms, schools and background will provide high levels of external validity (Merriam 1995) and distant relevance, particularly in the Irish context. In addition, it is argued by O'Donnell (2004) that an intervention can be seen as credible if it can be replicated with multiple groups, something the pilot revealed as a requirement in the next design iteration. Data collection methods follow the same protocol as the pilot phase pertaining to the researcher reflections and the observation schedule, however, amendments have been made to the semi-structured interview tool. As core design sensitivities, derived from design cycle 1, students' prior knowledge, the relevance and cross curricular link design strategies now form distinct questions in the new semi-structured interview tool to highlight them as areas of inquiry per the iterative qualitative design (appendix C). Classroom observations following the same schedule as before will be conducted by the primary researcher when the third hook intervention takes place in each teacher's classroom. This is to allow teachers to develop an instructional strategy to use in association with the video in a complete naturalistic context. Teachers may also want to practice and familiarise themselves with the technology as design cycle 2, allows the teachers to use any teaching strategy they wish. Thus, based on their pedagogical knowledge and beliefs (Awan 2012, Law 2009, Weld 2004), teachers may experiment and attempt to figure out the best way to implement the hook video in their respective classrooms. According to Hooper and Rieber (1995), when introduced with any new technology, a teacher goes through a number of phases. The first is familiarisation. This process is concerned with one's initial exposure to a technology. It involves the 'how's' and 'whys' of the technology and allows the teacher to form their own ideas pertaining to the technology. The second phase is utilisation where the teacher attempts to use the technology for the first time. Effective Integration is the next phase, and is described by the authors as (Hooper and Rieber 1995) the 'break through' phase. This occurs when a teacher uses technology for certain tasks and responsibilities in the classroom. The methodology, therefore, was specifically designed to accommodate familiarisation and integration of the video hook technology. The methodological changes between design cycle 1 and 2 are summarised in table 6.1 below.

Table 6.1: Summary of methodological changes between the design cycle 1 and design cycle 2

	Design Cycle 1	Design Cycle 2
Participants	Pre-Service Teachers	In-Service Teachers
No. of participants	2	10
No. of interventions	2	30

The largest change is that teachers will be implementing three interventions as opposed to one. The rationale behind this is that teachers in this phase are being asked to develop and utilise their own pedagogy in association with the video. Previously, the study attempted to integrate theoretical positions into the practical and naturalistic contexts of the classroom. However, this phase will take the opinions and practical efforts of teachers and discern what works in a fluid and complex environment by bridging it back to theory in line with the DBR paradigm. Three interventions per teacher, with a variety experience, classrooms, demographics will allow teachers to test out a variety of strategies and determine what works best in association with the video hook design. The end of the phase will total a minimum review of thirty hook interventions. This will allow teachers to become familiar with the physics video hook content and design. It is hoped that their knowledge of both the hook and naturalistic context of their classroom will inform and expand upon all aspects of the study.

The methodological changes in phase 2 may also inform the study from a chronological perspective, which was not possible in Design Cycle 1. Three hook based interventions with the same class may have cumulative effects, or otherwise. Over the course of the study, teachers may notice that the more they use the hooks, the greater or lesser their impact. This could have important consequences for interest (Ainley and Ainley 2011) development in which it is asserted that the constant triggering and creation of situational interest can potentially lead to the development of individual interest among students (Hidi and Renninger 2006).

Another advantage in relation to maintaining the naturalistic context of the classroom in design cycle 2 is that teachers are allowed to implement the first two hook interventions in their own time, without outside interference from the data collection tools or researcher. Hence, the teachers will have time to develop some of their opinions on the hooks well in advance of the interview and observation which many of the teachers documented in emails to the researcher after

the interventions. This means the first two interventions are as close to the normal and natural state of the classroom as possible and the data derived will closely represent the complexity of said class (Barab 2006). This may be pivotal in reducing potential Hawthorne effects in which an intervention may simply be a success due the attention placed on participants (Brown 1992). Emails will be used to take record of what hook the teacher used, the teaching strategy employed and the teacher's perception of the student reaction during the first two interventions. This should aid in the overall goal of the project in aligning theory with practice in the creation of a proto-theory that is workable by both researchers and practitioners.

6.5 Findings Summary

Evidence from the findings section detail the student impact of the hooks in terms of initial attention leading to confusion. Data points to the reaction having manifested due to restrictive pedagogy based on theory in which teachers could not expand or modify their instruction as they would have endeavoured based on their interpretation of the physics video hooks. In addition, teachers presented two broad explanations for the students' reaction. Firstly, prior or background knowledge was positioned as something students required, to enable a successful hook intervention. Secondly, the role of certain design features in creating confusion, the cross curricular links and relevance design strategies embedded within the hooks was underscored. It was thought that the former strategy lead to confusion as the video was at too high an academic level and students could not connect, what in their minds, were isolated topics. The latter, however, instigated that the relevance strategy was not strong enough within the videos and students were left asking 'what is the point in this?'

Given this, the pilot phase highlighted future themes and theories that may become central to further design cycles. These findings will be further advanced in design cycle 2 or the mainstream phase. This phase will conduct more interventions, however, it will adopt the findings of the pilot into the new interventions. The aim will be to continue to receive feedback on the implementation of the physics video hooks. The exact changes are detailed in the upcoming sections. Summarising this phase and the findings, in terms of the hook intervention, the proto-theoretical framework developed is diagrammatically represented in figure 6.4 below. It encompasses intervention modifications from a physics video hook and pedagogical design

perspectives grounded in the findings of design cycle 1. It will be the framework examined and progressed in the forthcoming design cycle.

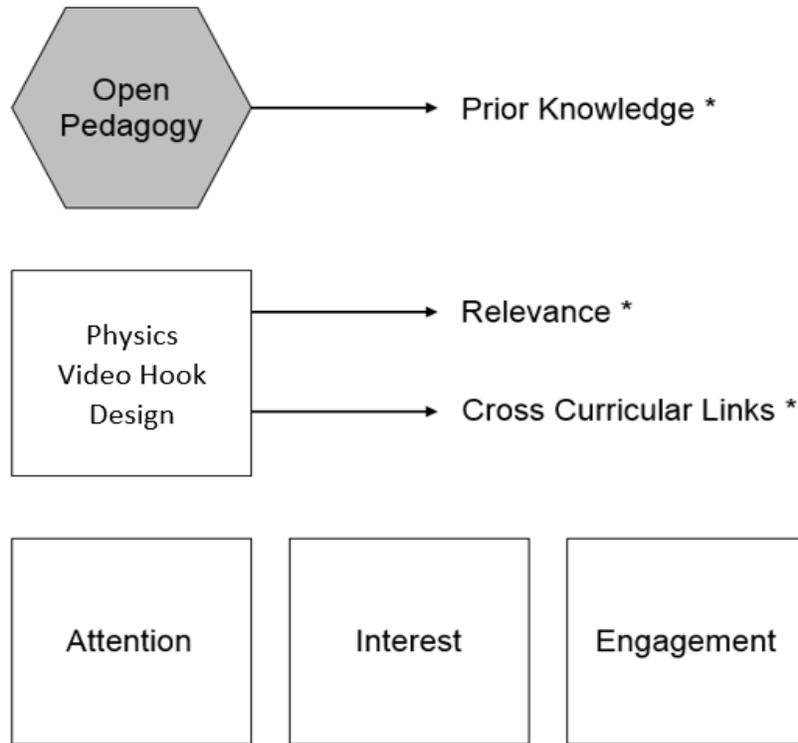


Figure 6.4: Diagrammatical representation of proto-theoretical framework developed from design cycle 1. * Denotes design sensitivities that have not been modified, but will be examined further in the next design phase

6.6 Chapter Summary

This chapter has discussed design cycle 1 when the video hook intervention progressed from theory to practice in an initial foray within the junior science classroom. The chapter firstly outlines the grounding of design cycle 1 in its ‘cobbled’ theoretical formation and then explains how the hook intervention was expanded into pre-service teacher’s classroom. The findings were framed and discussed in terms of pedagogy, student impact and video design. Evidence was presented in both confirming and disconfirming manners to illustrate various phenomena throughout the intervention. The next chapter, design cycle 2, represents the second design iteration of this

Chapter 6: Design Cycle 1

research project in which the findings of the pilot will be mainstreamed. It will test and advance the theoretical and practical developments outlined in chapter 6.

Chapter 7: Design Cycle 2

7.1 Chapter Introduction

This chapter will discuss design cycle 2 in which the hook videos were implemented on a wider scale with in-service secondary science teachers from across Ireland. The chapter presents a structured narrative of how the video hook design was altered leading into the second iteration. Firstly, the implementation process for Design Cycle 2 is discussed (7.2), followed by the resultant emergent themes and findings (7.3), concluding with research informed changes towards Design Cycle 3 (7.4). Evidence will be discussed with exemplars of data to illustrate the impact of the video hooks on the classroom ecology. The discussion is initially framed in terms of the teacher participant approaches to integrating the video hooks into their classrooms with concurrent analysis and overlap with the physics video hook design sensitivities and the student impact.

7.2 Design Cycle 2: Implementation Strategy

7.2.1 Overview

This intervention and associated research methods have been developed to answer the primary and subsidiary research questions;

How can physics video hooks be designed and implemented to generate student attention, interest and engagement in physics?

a) Does teaching with video hooks have the potential to target junior science students' attention, interest and engagement in physics lessons?

(b) If so: what are the integral components of physics video hooks from both technological and pedagogical design perspectives that shape the development of student attention, interest and engagement?

To answer said questions, the physics video hook intervention was further deployed in design cycle 2 with in-service teachers from across Ireland. The goals of phase 2 are to advance the results of pilot phase. The pilot unearthed key findings, particularly in relation to teacher needs and constraints within the junior science classroom. As discussed in the previous chapter, participants felt restricted by the hook teaching methodology. Their perceptions and the results derived from observations revealed that the suggested hook teaching method did not align with the video hook design. From the teacher's perspective, the video hooks proved to be abstract and academic for the

students to fully grasp. Without comprehension, the majority of students did not express persistent interest or engagement in the video content. The associated impact on the students was confusion as opposed to the intended outcome of hooks, the development of attention, interest and engagement. Within design cycle 2, the focus now turns to scaling up from the design cycle 1, making changes based on results and forwarding theoretical and practical developments on a wider scale per the phased DBR strategy set out by Long and Hall (2015). In achieving this, design cycle 2 specifically targets in-service teachers from across Ireland to participate. Consequently, numerous alterations to the intervention design were warranted. The following subsections will delve further into the pertinent modifications made in terms of methodological, pedagogical and physics video hook design.

7.2.2 Pedagogical Design

Grounded in theory, utilising the video at the start of class did not provide a platform for the integration of the hooking mechanisms embedded within the video technology into the classroom. The pilot highlighted a conflict between theoretical positions of the pedagogy associated with hooks and that of the current design. Thus, intrinsic to the hook design is a theoretical and ideological incongruity which the next phase of interventions in design cycle 2 aim to ameliorate. Lending credence to the above argument is that one of the teachers noted the role that prior knowledge could play in aiding students to fully conceptualise the videos. He positioned background knowledge as a key in student understanding. Given the above opinions, the following pedagogical modifications should allow for teachers to employ the video hooks in an unrestricted manner, based on their beliefs, experiences and classrooms. This will enable prior knowledge, along with other emergent design sensitivities to be compounded or alleviated through further examination.

The major design change for pedagogy in phase 2 is that teachers are asked to develop and employ their own pedagogical strategies to use in tandem with the video hooks. In sum, an open pedagogy is now being implemented in design cycle 2. Teachers are asked to integrate the video hooks however they deem appropriate pedagogically, based on their experience and their class. The goal of the hook is still to augment attention, interest and engagement, however, teachers may utilise the video in multiple ways, according to their own teaching style and learner needs, providing incremental opportunities for learning.

7.2.3 Physics Video Hook Design

Based in the data derived from the previous phase, no changes have been made to the physics hook design. However, a number of potential design outliers were flagged with particular reference to the cross curricular links and relevance strategies within the videos as design sensitivities that potentially require re-examination and amendment. Further qualitative feedback on these areas will be sought after in design cycle 2 with specific questions pertaining to these areas being added to the semi-structured interview.

7.2.4 Intervention Design Modifications

The changes to the intervention design were based upon the pilot phase findings. Therefore, the amendments are broad stroke changes with the goal of advancing hook theory and practice in a naturalistic context. The proto-theory developed from the pilot is represented in Figure 7.1.

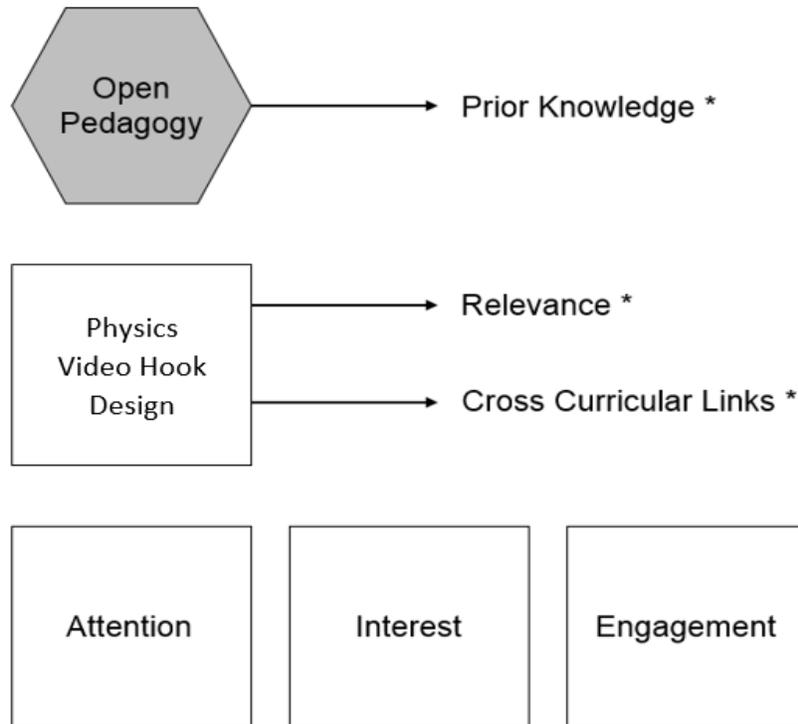


Figure 7.1: Diagrammatical representation of proto-theory derived from the data in design cycle 1 (pilot) being implemented in design cycle 2. * Represents design sensitives being examined in this design cycle

The above theory was developed in design cycle 1 and is utilised throughout design cycle 2. As can be seen from the diagram, the main changes from a theoretical perspective are based around

pedagogy while the other elements remain unchanged, some such as cross curricular, links, relevance and prior knowledge became focal points of this iteration.

7.2.5 Conjecture Map

The conjecture map for design cycle 2 (figure 7.2 below) represents the current intervention and predicted path based on the design artefact and theoretical derivations in this study with the speculated outcomes.

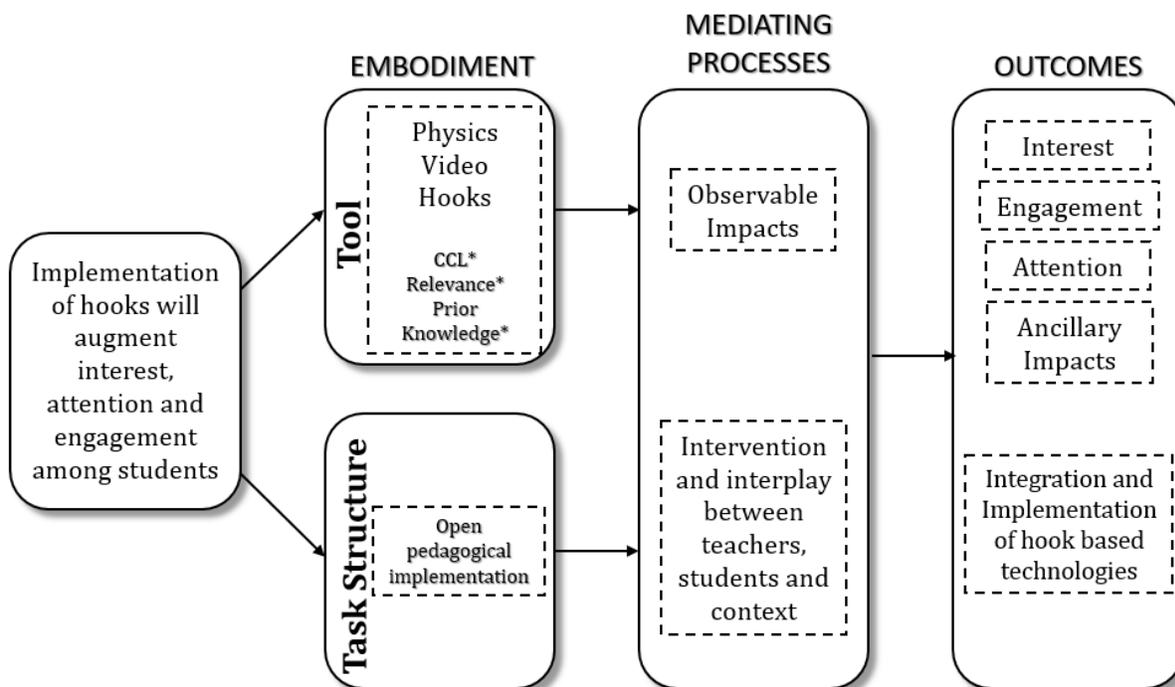


Figure 7.2: Conjecture map summarising the enactment of; and predictions in design cycle 2. *CCL refers to Cross Curricular Links

7.2.6 Methodology

Grounded in the findings of design cycle 1, this phase requires a modified methodology that allows for the further advancement of hook theory and design. Design cycle 2 takes the same form of qualitative intervention, however, three interventions will be conducted in every teacher's classroom as opposed to one previously. Teachers will be asked to use a minimum of three physics hook in their junior science classes over a period of four months from the suite of eleven videos. The rationale behind this is that teachers in this phase are being asked to develop and utilise their own pedagogy in association with the video. During this phase, ten secondary science teacher participants from across Ireland will be recruited for the study using a purposive sampling frame.

Data collection methods follow the same protocol as the pilot phase pertaining to the researcher reflections and the observation schedule, however, amendments have been made to the semi-structured interview tool. Classroom observations following the same schedule as before will be conducted by the primary researcher when the third hook intervention takes place in each teacher’s classroom. This is to allow teachers to develop their own instructional strategy to use in association with the video in a complete naturalistic context. Table 7.1 summarises the methodological changes from design cycle 1 to design cycle 2.

Table 7.1: Summary of methodological changes between the design cycle 1 and design cycle 2

	Design Cycle 1	Design Cycle 2
Participants	Pre-Service Teachers	In-Service Teachers
No. of participants	2	10
No. of interventions	2	30

7.2.7 Data Analysis

Data analysis for the design cycle 2 followed the protocol set out in the methodology chapter. As in the pilot phase, items for analysis included systematic observation reports, semi-structured interviews and researcher reflections written directly after the observations and interviews. All of the data collected was coded using manual methods for first cycle coding and NVivo data analysis software for second cycle coding (appendix D demonstrates the development of sub-codes to categories and themes) (Saldaña 2012). The hybrid thematic analysis (Clarke and Braun 2013, Saldaña 2012) was utilised to develop a thematic map for the design cycle 2 (figure 7.3). Within the map, the focal points are design, impact (student) and pedagogy with associated offshoots identified in line with the research objectives and emergent data. Arrows and associations display how themes interacted with one another throughout the phase. The thematic map is derived from evidence within coded data. It informs the interplay between thematic and theoretical considerations throughout the second phase of research. The themes derived from thematic analysis and the entire coding process are discussed within the findings section and elaborated upon and explained with pertinent literature. It can be readily observed in the thematic model of the second phase, that through an iterative design change, the hooks have been integrated effectively into classrooms with a desirable impact on the student body. The map provides an overview of the following findings section, which will firstly deliberate the pedagogy of the intervention and develop the discussion further into other thematic areas of significance.

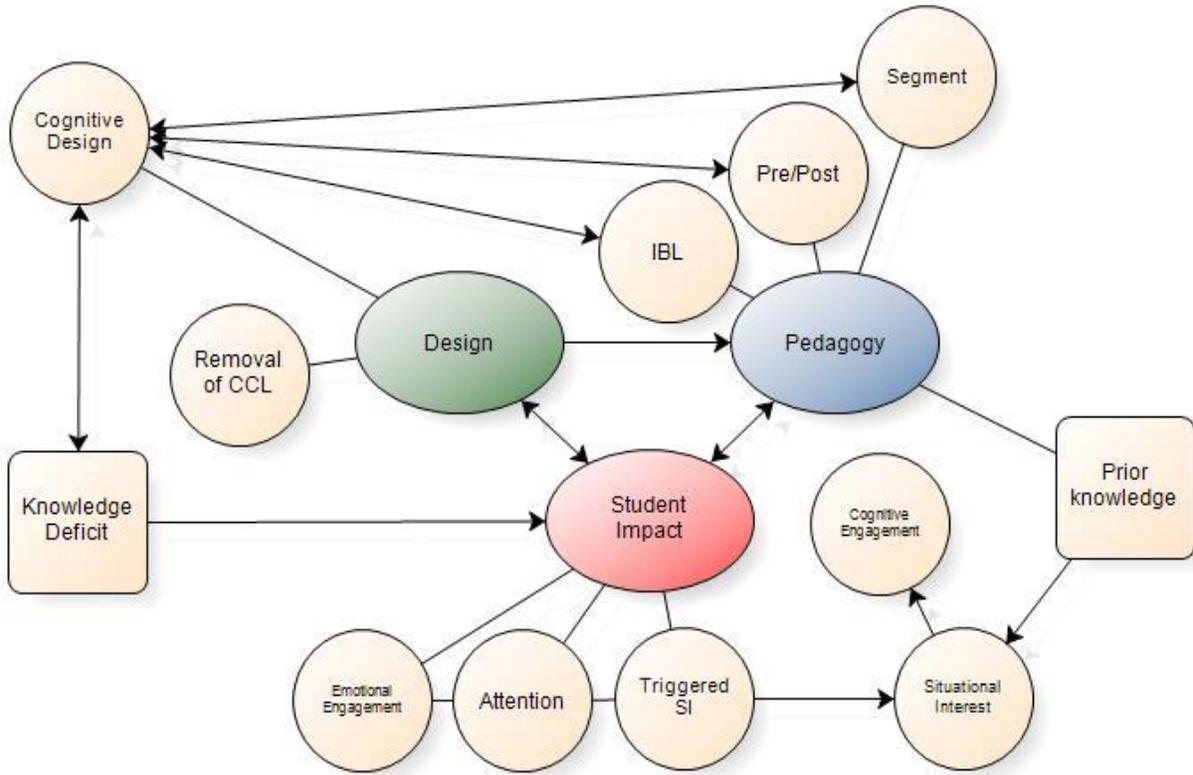


Figure 7.3: Thematic map derived from data in design cycle 2

7.3 Design Cycle Two: Findings

Findings from the interviews, observations and reflections derived from the multi-site teacher interventions are presented here. Findings are represented as emergent themes abstracted during data analysis. Firstly, the pedagogy utilised by the participants will be discussed in light of their pragmatic classroom goals. Secondly, the student impact will be elucidated with regard to knowledge gaps leading to the development of situational interest. Throughout, both themes will be illuminated by making reference to the physics video hook design. Finally, the communal theme of prior knowledge development within instruction across all interventions will be demarcated with links to both pedagogy and design.

7.3.1 The Scientific Method: The Pragmatic Implementation of Physics Video Hooks by Science Teachers

The implementation of the physics video hooks into the science classrooms revealed that teachers were pragmatic in their application of the new technology. The teachers examined the hook videos

as an instructional tool and then decided how they would employ the videos in class to fulfil their teaching and learning aims along with lesson goals. This practical process of systematically examining both the hook and the classroom requirements is summarised below by one of the teacher participants.

Eva: *“I would think alright, that one doesn’t fit with the lesson plan that day, so what will I do? So it definitely made me think a little bit more about hooking at the start of a lesson, then the other thing was as I started to go through the videos, I started to say, right, I don’t think I would use it at the beginning, I think I would use it like maybe today, as a summary extension activity, like can you guys now look at equipment and come up with a way to link the equipment together...”* (Interview IE215)

This quote from Eva demonstrates the emergence of metacognition with regard to teachers practice in this phase. When asked to implement an open pedagogy, teachers took account of their context and students in attempting to ‘fit’ the video hook into their lessons. Aldunate and Nussbaum (2013) state that the adoption of technology by teachers is a dynamic process of cost and benefits transactions. Teachers rely on their core beliefs when determining classroom actions (Wallace and Kang 2004). With their vast classroom experience, teachers construct an integrated set of values and beliefs that greatly determine their practice (Awan 2012, Davis 2003, Law 2009). Pertaining to science teachers specifically, their decisions in the classroom are determined by experiential knowledge, formal knowledge and personal beliefs (Van Driel *et al.* 2001). A teacher’s view on how science should be taught is based upon a priori of knowledge and experience (Weld 2004) and this proved to be true for participants in this phase. Hence, the argument can be made that the participants utilised a ‘scientific method’ when implementing the videos. That is, an experimental approach to see what works. This is further evidenced by Eva who asked in relation to the videos:

Eva: *“Where will it fit and then kinda saying like, what is the value if it, what are they going to gain from that?”* (Interview IE215)

Another teacher participant, Aisling, expands on the metacognitive approach by explicitly reflecting on her class, their ability and age when instigating pedagogies with the hook.

Aisling: *“...but if you do the video right, use it appropriately em, link it to the learning, get the kids to get something out of it...”*

Chapter 7: Design Cycle 2

Researcher: “Ya”

Aisling: *“beforehand, I, I didn’t go down that line because for that video, just for the first years, I didn’t think it was, was the best strategy.”*
(Interview IA15)

The idea of fitting the hook into the lesson in conjunction with student requirements was continually apparent. In this next instances, Emma and Helen were asked about when and how to use the hook in class. Their responses align with the arguments made by Van Driel *et al.* (2001) and Weld (2004) above in relation to how science teachers rely on their experience when creating their lessons.

Emma: *“However I see fit, I like to fit things in when it suits and that one, like if I was teaching the lesson again, I might try it again in a different way, but I liked the way it worked.”* (Interview IE115)

Helen: *“Well I suppose I know when I start sort of putting the class together do you know what I mean, I would look and see well where will that fit in you know...”* (Interview IH15)

As is evidenced in the data, the teachers embraced the open pedagogical strategy in which they were invited to apply their own instruction in association with the physics hooks. They did not treat the videos as hooks, rather they approached them as a teaching and learning resource. Therefore, their primary focus was not necessarily on the development of interest per the physics video hook design. More commonly, teachers would employ the hooks for consolidation of learning, differentiated learning or for revision. In various instances the hook videos were described as multi-tools, a video that can be used for a variety of purposes in class depending on the pragmatic needs to the teacher at the time, as Emma notes;

Emma: *“I think they are adaptable that you can fit them in depending on your teaching strategy, depending on your class...”* (Interview IE115)

The teacher participants took ownership of the videos as their teaching tool and adopted them for their own needs. This adds credibility to the methodology implemented during this phase and denotes the high level of intuitive understanding teachers have of their classes, and developed in terms of the video hooks. The teachers embedded the hooks into their lesson plans through an experience based process in accordance with their needs. This allowed for the adoption of a diverse

range of pedagogies demonstrated by table 7.2. The table lists the range of instructional strategies or combination thereof employed by the teachers in this phase. The following section will investigate and discuss each strategy with examples from the data and pertinent literature.

Table 7.2: List of teacher participants and the teaching strategy they employed during Design Cycle 2. The numbers denote how often the strategy was used in the sample of ten

Teacher Participant	Teaching Strategy
Aisling	Pre/Post (6), Segmentation (3)
Bill	Pre/Post (6), Guided/Structured IBL (3)
Catherine	Pre/Post (6)
Denise	Guided/Structured IBL (3), Segmentation (3)
Emma	Pre/Post (6)
Eva	Guided/Structured IBL (3), Segmentation (3)
Helen	Post Revision Strategy (2)
James	Pre/Post (6)
Richard	Pre/Post (6)
Yvette	Post Revision Strategy (2)

7.3.2 Pedagogical Strategies

The following is an extract from an observation report of a hook intervention.

The teacher then moves onto the hook video which is played in the last fifteen minutes of class after spending the previous sixty minutes working through questions and examples of energy conversions.

Teacher: *“I am going to show you part of this video, now that you are experts! You have to listen really carefully.”*

As the video plays, one student is dancing to the music, but on the whole the class is quiet. The video hook displays an experiment which asks, how can you convert chemical energy to kinetic energy with certain pieces of equipment. The teacher pauses the video after the equipment is announced and also shows the equipment in a physical form to the students. Students are placed into pre-set groups and are then asked to come up with the answer to the question (How do you convert chemical energy into kinetic using the equipment displayed in the video?) by developing the correct methodology. They have 5 minutes on the clock. The clock is placed on the projector screen. The method being employed by the teacher asks groups to apply their previous knowledge in reverse. Their running knowledge is

Chapter 7: Design Cycle 2

on energy conversions when given the object, i.e. a toaster converts what type of energy to what? Now, they are given the conversions and asked to configure the objects in a correct manner. The students are working out how to convert chemical energy to kinetic. The teacher reinforces the goals of the learning tasks. Students are talking about their different theories in groups.

Students ask questions like; “Is there coke in the can?”

They students are highly attentive as they compete to figure out what’s going on.

Teacher: *“you have to be able to explain it with your group.”*

Students are coming up with theories and hypotheses. The hook is being used as a consolidation tool for the learning, students are applying what they have learned in class. Every group then gets 30 seconds to explain their theory before the rest of the video is played. The video in this instance is a vehicle for delivering particular teaching goals. No students come up with the correct answer, however one group is closest and wins, the teacher plays the rest of the video, during the video some say ‘oh’ and ‘coool’ when they see the answer to what they were working on.

Student B: *“ya, that’s cool, it’s like a jet.”*

Student C: *“Can we do that tomorrow miss?”*

Teacher: *“The winning group can put it together for the class tomorrow.”*

Winning group: *“Yesssss!”* (Observation ROE215)

As can be seen in the above excerpt, the video hook was fully integrated into the complexity of the teacher’s classroom through a segmentation process. However, the result poses the question, can the videos still be regarded as hooks, or at this point are they an extension of a hooking methodology? Indeed, the video was the fulcrum around which the pedagogy turned. The video design, enabled the teaching strategy and that strategy enabled the reaction from the students. This is something that the teacher in this instance not only recognised, but employed successfully in her class. Furthermore, this observation extract above denotes the first instance of a student reaction to the video in accordance with hook theory. One can identify areas in which, students interest may have been triggered on a number of occasions, especially through their “Can we do this?” reaction (see 7.3.4). The development of associated pedagogy by the teacher participants as a sort of ‘para-hook’ was vital to the effectiveness of the intervention. According to Lavonen *et al.* (2005,

p. 73) “Situational interest is aroused as a function of the interestingness of the content and context and partially under the regulation of teachers.” Therefore, one can derive the crucial nature of the teacher’s facilitation of the student impact within this study. Additionally, the teacher input was of particular importance due to the hooks video format. Duffy (2007) states that effective instruction with video should utilise it as a vehicle for learning through good teaching practices. Video can forward learning goals, but it cannot achieve this independently as it needs to fit a classroom correctly (Bravo *et al.* 2010, Karppinen 2005) by matching it with instructional goals (Bell and Bull 2010). Learners do not gain insights from just watching a video. Viewing must be done with a clear purpose in mind. It should address specific goals and be woven into the fabric of a lesson (Borko *et al.* 2008). The videos represent one component of the complexity of a classroom system. It is thought that video lacks a key component of interactivity (Karppinen 2005) and teachers were cognisant of their role in achieving an active learning environment.

Bill: *“I think showing the hook on its own you know, won’t get there, doing it on its own definitely doesn’t get it there...”* (Interview IB15)

Catherine: *“the hooks are great, but you’ve got to make them (students) think and you’ve got to make them work and you’ve got to make them ask questions around it...”* (Interview IC15)

These were common sentiments and in every classroom, students were encouraged to actively work with the videos. In addition, the hook, rather than being used as a ‘starter’ was instead used as a ‘main course’ in class. Teachers were pragmatic in their utilisation of the video and often the class or half of the class was built around the video. One of the teachers noted;

Helen: *“I would look and see ‘well where will that fit in?’ you know what I mean.”* (Interview IH15)

Fitting the hook into their schemes of work was conducted in a variety of fashions. Overall, the strategies fall into one of four categories. These include; pre/post methods, inquiry based approaches, segmentation and post revision strategies. Each category will be detailed presently with examples from the data.

7.3.2.1 Pre/Post strategies

In approximately half of the observations, teachers either employed a pre/post strategy or mentioned in interviews how they used said strategy in a previous hook intervention. The

popularity of this technique may be due to its simplicity and effectiveness. Additionally, this strategy is particularly suited to video as viewers will be active in their engagement with the content. A typical example from an observation is below;

The teacher then moved onto the hook video and placed two questions on the board.

1. *What does the video tell us about sound?*
2. *What occurs in the video and why?*

Teacher: “I am just going to show you something, bear in mind the two questions”. (Observation ROE115)

This was a very simple strategy that had students actively working with the sound hook. The teacher then questioned students afterwards on their answers. Bell and Bull (2010) add weight to the suitability of this strategy by suggesting that prior to playing a video, students need to be told what to look out for and a conclusion needs to be drawn together afterwards. Students can be actively engaged by asking them to answer a question and interpret a message within a video (Bell and Bull 2010). Another teacher summed up why she implemented this technique;

Catherine: “...and you see there now I was asking the questions afterwards, but if you ask them before, they’re already thinking you know...and as they figure out what’s going on, you can see someone writing frantically because they’ve got it.” (Interview IC15)

An argument could be made against this strategy in that it can be cognitively demanding to answer questions and try to fully comprehend the hook. Perhaps this is why a student may be ‘frantically writing’, however, the students were primed in terms of prior knowledge and key terms to look out for before working on the activity. Another issue with pre/post techniques is that throughout observations some students would forget about answering the questions and were totally fascinated and focused on the hook. However, once the video had finished, they would remember the task and start writing quickly to complete their assignment. This was the simplest strategy employed by the teachers and proved to be highly effective.

7.3.2.2 Inquiry Based Learning

Within a number of the classes, teachers employed a guided or structured Inquiry Based Learning (IBL) strategy in association with the video. Often the video was paused so that students did not have all the necessary information to complete the activity, hence the IBL was structured in nature

as they received the question and procedure (Colburn 2000). In other instances, guided inquiry was utilised whereby students were told the question from the video hook, and had to create the methods and results (Colburn 2000). These types of inquiry inspire curiosity through student centred problem solving, critical thinking and questioning (Savery 2015). Such approaches, often begin with a question or problem followed by a practical investigation. In the observations, the hook was used to pose the problem and then students began an investigation to figure out a concept or phenomena in the video based on their own knowledge. In other instances, teachers would play the video and get the students to recreate what they had seen through trial and error. The IBL strategy was an effective accompaniment to the hook as the literature notes how experimentation and IBL encourage interest and engagement in the classroom (Arnone *et al.* 2011, Bergin 1999, Edelson *et al.* 1999, Hampden-Thompson and Bennett 2013, Regan and Childs 2003, Zahorik 1996). An example of an IBL strategy implemented in one of the classes is described below with segments from the observation report.

Teacher: *“Today, we are only dealing with that gravity on earth, the COG is where all gravitational force appears to work. First thing, how do we actually find the COG of a piece of cardboard? Books closed! Can I balance this on my finger?”*

The teacher attempts to balance a piece of cardboard on her finger.

Teacher: *“We have some basketball players in this class, how do you spin the ball on your finger?”*

The students will be trying to find the COG of a piece of cardboard the teacher is cutting out of an old box

Teacher: *“What shape do you want?”*

Student: *“A circle”*

Teacher: *“I can hardly cut a straight line never mind a circle!”*

In the first half of the class, the teacher elicited the students’ prior knowledge and connected the topic to their personal lives. The students are also building up experiential knowledge of gravitational forces and balance. The class continued;

The class then get a bunch of equipment for the experiment and begin to try and figure out the exact COG of a piece of cardboard. Students start to work as they get aprons and goggles. The experiment was an IBL learning strategy and the

teacher gives them a clue every few minutes. Moving on from this activity, the teacher plays the first half of a hook which asks “How do you find the centre of gravity between a fork, a spoon and a toothpick?”. The teacher pauses the video at this point and continues with the IBL strategy.

Teacher: *“Now that you know about COG, I want you to find the COG of a fork, spoon and toothpick.”* (Observation ROD15)

Students continued to work with the equipment to figure out the experiment. After five minutes or so of experimentation, the teacher then played the rest of the hook and the students reaction was in line with the hook impact model (7.3.4). The class worked with their prior and running knowledge to build new knowledge about the centre of gravity. This was key as when the students saw the hook, not only could they fully comprehend the scientific principle of the video, but they also recognised when the phenomena in the video did not make intuitive sense based on their prior knowledge and experience. It should also be noted that the teacher above combined the IBL strategy with a segmentation or pausing strategy. The segmentation strategy was a key technique that was employed by the teachers, often in conjunction with the previously described pedagogies. It will be demarcated in the following section.

7.3.2.3 Segmentation

As can be seen in the inquiry based learning section, many teachers paused or replayed the video hooks for a specific teaching purpose or learning goal. This is a technique known as segmentation. Segmentation is the process of showing a visual in pieces rather than in a continuous flow (Khacharem *et al.* 2013). It divides content into several segments of information so that students get a ‘bitesize’ delivery of information (Ibrahim *et al.* 2012, Fill and Ottewill 2006). Learners obtain additional time to process information (Khacharem *et al.* 2013) through the reduction of cognitive load (Ibrahim *et al.* 2012, Ljubojevic *et al.* 2014). As can be seen in the following data, teachers advocated the pausing and replaying of the videos.

Bill: *“...you can watch it through and you can stop it and you can, it shows focusing on something and you can stop it you can move on, you can you know rather than kinda ‘voooomp’ you show it all and they have only picked up 10% of it, you can stop it, right go back and we step through this...”*. (Interview IB15)

Eva: *“...and I know in choosing to pause it, I think teachers will just press play and then when its finished say, right, what did we learn?”*

Chapter 7: Design Cycle 2

And it's too late then, you might have those misconceptions in there whereas, I think if you said optional, pause the video here if you want and ask your partner, your encouraging them to get them to be doing exactly what they should be doing, which is collaborate.” (Interview IE215)

The sentiments of the participant are in line with the literature pertaining to teaching and learning with video (Bell and Bull 2010, Berk 2009, Fill and Ottewill 2006, Shephard 2003). However, rarely does the literature give advice on teaching strategies that can be used when the video is paused. Teacher participants employed a wide array instructional techniques in association with segmentation including, think pair share, group work and more commonly predictions. The following is a typical teaching scenario;

The teacher pauses video

Teacher: *“Let’s do a quick vote, who thinks the coke will float?”*

Students are putting their hands up. The students are getting to give their opinions and are shouting up answers.

Video is resumed

When the students were watching the video, they let out shouts of “yay” and “yes” as they express contentment with getting the correct answer. (Observation ROA15)

Prediction strategies were tested by Crouch *et al.* (2004) who varied two types of scientific demonstration. The first was a standard demonstration in which students just observed. The second was a demonstration in which students were asked to predict what would happen. The involvement of the student in the activity led to increased engagement and understanding. The former study reflects the first and second phases of this research. In the pilot phase, students were passive, they demonstrated little interest or engagement in the video and found it confusing. However, in phase 2 they were actively engaged with the hook content. Pedagogical techniques such as the prediction strategy above were one of the key differences between phases in this study in terms of engaging students and getting them to work with the video. However, the largest difference in terms of the teaching in the pilot and the teaching in this phase was the time teachers spent developing the students’ prior knowledge before teaching with the video hooks (see 7.3.6). The final teacher pedagogy, the post revision strategy as only utilised by two of the teachers, however, it provides interesting evidence to support the theories presented in this chapter.

7.3.2.4 Post Revision Strategy

Two teachers in the study employed a post revision strategy. In these instances, Helen and Yvette used the video hooks as a revision tool. Similar to the pre/post strategy, the post revision strategy simply focuses on what happens after the video. Post the video hook, Helen asked questions about the video and then more general questions for understanding about the concept. Yvette employed a questioning strategy along with students developing their own mind maps using the videos for ideation and thinking time. In Helen's class, the students were interested in the content. The post revision strategy, although simple, was effective at garnering the students' interest (7.3.4). However, in Yvette's class, the reaction was muted, not negative, rather one of quiet concentration throughout and post the video. In fact, the hook reaction as described by the hook impact model (figure 7.8) was observed in every class barring Yvette's which instigated further examination of the data. Yvette's class was a deviant case in a number of ways. This will be delineated presently.

The teacher participants within the study were asked to utilise the hooks with a first or second year class, the intended target audience considered at video hook design stage. However, Yvette, could only contribute to the project by working with a third-year class. It was decided to incorporate her classroom into the study as a deviant example, with the hopes it would determine if the video hooks were relevant to incorporate with later year groups or exam years. Morse *et al.* (2002) notes that seeking deviant cases is pivotal in how it aids analysis, comprehension and completeness. Outliers and deviant cases are at the core of producing juxtaposed ideas and process (Barbour 2001) adding to the trustworthiness of the research as a type of confirming and disconfirming data have been investigated (Morse *et al.* 2002). Third year is an examination year, whereas the lower years are not. It was found through examining the data that Yvette's teaching and student reaction was different to the other teachers in the study.

As previously described, Yvette employed a post revision strategy in each of her three interventions. Her implementation of the videos was in line with the other participants as she pragmatically used the video to suit her needs and students. The videos provided a quick way to revise a topic. This need for a revision tool was apparent in discussions with the teacher and was noted in the following researcher reflection;

“She seemed to want very curricular videos that were exam focused and could be used as exam revision material. She also wanted videos that were from the mandatory experiments.” (Reflection RRY15)

The teacher was seemingly not alone in her practical mind-set as the students were exam focused and judged the hooks accordingly. I noted in a reflection that the students saw the hooks as “study aids” (Reflection ROY15). The teacher confirmed this and noted how the students would have liked more content in the video, with more narration and explanation. She stated;

Yvette: *“...they’re looking for something immediate and now and what’s, what’s on the (exam) paper.”* (Interview IY15)

This is opposed to the other students in the study who were not in an exam mind-set. Changes in student perceptions were investigated by Smyth and Banks (2012) who report on the fleeting nature of student opinions. It was found that as students approach exams, they perceived exam focused teaching methods as ‘good teaching’, whereas previously describing them as ‘inauthentic’ (Smyth and Banks 2012). This is not to say that the students were not positive regarding to the video hooks, however, their reaction was muted. They were totally focused on their revision for their exams and the hook was a tool for that purpose in their minds. This is something that was readily observable with this deviant class and demonstrates how the hooks were effectively and intentionally designed for younger year groups when situational interest is malleable (Darby 2005). Archer *et al.* (2010) posits that by age 14, students’ perceptions of science are already formed. Hence, their reaction to the hook was not in keeping with the younger groups (see 7.3.4). The deviant case adds weight to the research in terms of external validity (Merriam 1995) as the specific intervention was successfully replicated in the targeted classrooms. This adds credibility to the research phase and methodology implemented as O’Donnell (2004) posits that comparison groups verify and corroborate findings. In this instance, this proved to be the case in relation to the teacher’s pragmatic mind set and the intended focus of the hook design for younger year groups.

7.3.2.5 The Scientific Method: Continued Pragmatism

The final finding from this phase that links back into the overarching emergent theme of science teacher’s pragmatic philosophy in the classroom is that when the participants were asked, if you could design your own hook, what would you make, and what would you include? They generally responded by intimating that they would want more hooks, covering a wider variety of topics and in particular topics that students struggle with or have little interest. Participants had found a niche

for the hooks in their class, even though the argument can be constructed that the teachers did not use the videos as ‘hooks’. Eight of the ten indicated in interviews that they wanted more hooks, beyond the scope of the eleven videos. Bill highlighted this issue in his interview;

Bill: *“I suppose for me, there is a greater need to have like additional hooks...”*
(Interview IB15)

Building on this, three of the eight teachers who wanted more videos identified the specific area of electricity as requiring a hook. This demonstrates how teachers were able to reflect on their teaching needs and desired the benefits of the hooks in areas they deemed potentially more difficult to teach or an area in which students struggle as Catherine indicates;

Catherine: *“electricity and electronics, has to be, has to be the one that gets them here all the time.”* (Interview IC15)

The teachers’ metacognition with respect to their own teaching and their classes requirements are plain to see in the data. Adding to this theme is that four of the teachers indicated that they would continue to use the hooks in their teaching beyond the research timeline and were thankful for the hooks as a teaching resource. One teacher, Emma, noted how she would further test the videos and continue to use the most effective ones, the embodiment of pragmatic scientific method.

Emma: *“I probably would try them all once and then the next time I am doing it pick the better ones.”* (Interview IE115)

Denise: *“Well I definitely plan on using them going forward anyway now so like I hope to keep going with them...”* (Interview ID15)

Both sentiments are an excellent indication that the hook design was highly suitable for its target audience, particularly from a teacher perspective. Teachers are the agents of change within their own classes in terms of engagement (Darby 2005) and interest (Rotgans and Schmidt 2011b) and the continual use of the videos, demonstrates their effectiveness and how the research methodology in design cycle 2 has allowed for the integration of the physics video hooks into the authentic context of the classroom. One of the key findings with regard to the ‘open pedagogy’ instigated in this phase is that the teachers worked with and recognised the overarching hook design. Teachers were able to identify within the video key aspects of the design strategy and utilise it to forward their teaching goals. This will be elaborated upon in the following segment.

7.3.3 Design enabling Pedagogy

Evidence suggests that the full potential of technology is not being realised in formal educational settings (Bocconi *et al.* 2013). This is reiterated by Amiel and Reeves (2008) who state that education has changed less due to technology than any other facet of society. However, it can be argued that during this research phase, the videos, as technological artefacts, were successfully integrated into secondary school classrooms as described in the sections above. So, why is this the case? As observed in the previous section, the teachers' approach to the videos and their relevant pedagogies were not in line with the literature pertaining to hooks and this was the key in the integration of the new technology into the classroom.

In keeping with the practical approach, teachers examined the video hook design from a pragmatic lens. When participants were asked directly about the best and worst design features of the hooks along with how they would improve the design. The overarching response was in relation to the ease of use and practicality of the videos. This was also noted in design cycle 1 as the use of digital video as the hook medium made them easy to use and manipulate in class without any specialist training. Video is a well-established medium for communication in the 21st century (Fill and Ottewill 2006). Therefore, some of the most common problems with technology integration such as proficiency, self-efficacy and time constraints (Kopcha 2012, McGarr 2009) were not an issue. Video technology was seemingly commonplace within the teachers' classrooms and was an established part of the pedagogy as five of the participants used more than one video in their observed classes. With this, the teachers had informed opinions on what they wanted in terms of video technology design. They reported that the physics video hook design enabled the use of multiple pedagogies. Even though the videos represent an immutable design artefact, the open-ended nature of the hooks did not speak for the teachers or pigeonhole the video into one instructional application as noted by Catherine;

Catherine: *“The videos they leave room for further questioning and further investigations and you can see that there today [...] the strength in the clips that they say I think was the open-ended ness of them.”*
(Interview IC15)

A quote from Emma expands on this idea and demonstrates her thinking with regard to both the video design and the classroom context.

Chapter 7: Design Cycle 2

Emma: *“There is no words, there is no explaining, it’s all left up to the students’ interpretation so it develops the investigation (teaching method).” (Interview IE115)*

This establishes how the videos, although un-editable, were wholly adaptable. In this instance, the design enables the investigative approach of the teacher. Perhaps simple being the most apt descriptor from Helen;

Helen: *“I think it’s the simplicity of it, you know the simplicity of its short, its snappy and I love them” (Interview IH15)*

As can be noted in the data, the hook videos lack of specificity in terms of narration, with an explicit focus on scientific phenomena allowed for bespoke pedagogical exploration. Indeed, this was the primary design feature noted by participants that enabled the complete integration of the video hooks within the lesson and the implementation of a variety of teaching techniques was their reductive and cognitive design. This is what teachers referred to as ‘open-ended’ and ‘simple’. One teacher repeatedly referred to the videos as ‘short sweet and to the point’ which again highlights the pragmatic requirements of the classroom. The cognitive design of the videos pertains to the difficulty in understanding the learning material. Hence, the design attempted to reduce cognitive load by utilising various techniques. Videos were streamlined as much as possible by removing extraneous content, with the conscious awareness that a student’s attention is limited (Mazur 2016). Teachers noticed the reductive nature of the videos in terms of narrative, simple labelling and length. The videos also do not explain the phenomena they display and hence, the teachers labelled the videos as open-ended, something that was a positive in their minds.

Eva: *“I love the idea of the video being open, like you hold their attention, if you pause the video, we are going to see the end of that, if you guys get this right and I think, the video is so nicely produced, the kids are really like, this is a professional video, like, they’re into it.” (Interview IE215)*

Catherine: *“The strength in the, the, the clips that they say, I think was the open-ended-ness of them, you know?” (Interview IC15)*

Teachers were favourable toward a design that didn’t speak for them or set the pace of learning (Mazur 2016). They maintained control within the open-ended and flexible design and it allowed them to ‘fit’ the hooks into their class, however they deemed suitable. The strategy allowed

teachers to improvise around the video. The lack of an explanation in the hooks was favoured by the teachers and this was an explicit strategy built into the narration.

Expanding on the pertinent design features, teachers mentioned the length of the video, the content and their curricular design within interviews. One teacher noted about the hook videos;

Aisling: *“...they are absolutely spot on in terms of timing, they’re really nicely laid out, they’re very purposeful, very, they make the point you want whereas an actual video, I’d try not to use videos that are long anyway.”* (Interview 1A15)

The teacher notes how the length of the videos, content and timing is aligned with her pedagogical needs in class. The comparison is made between the hook videos and other videos a teacher may have to find on YouTube. Some teachers referred to finding a video on YouTube as ‘trawling’ (Trier 2007) and streaming video as not being completely safe in terms of content as noted by James.

James: *“you know they are safe to put on too like [...] if you have YouTube up, every so often you will see something (explicit) pop up there on the side”* (Interview IJ15)

In this excerpt, the teacher is directly referring to videos that are suggested on YouTube, the title pictures of which may not be appropriate for students. Another teacher participant discussed the problem of having to search for appropriate resources online.

Yvette: *“I try to get videos for most topics I can, I try to if I can, like if I can find one, but sometimes it is hard to find one that is suitable or appropriate, so that was the brilliant thing about the science hooks, because they are designed for you know, the junior cycle course.”* (Interview IY15)

Searching for videos is a long process and often the video found does not match curricular requirements. The participants continually noted how practical the videos were in terms of relevant content. A pertinent quote from one of the teachers summed up their needs;

Helen: *“...you know the videos are leading into the course and either they’re leading in or they’re leading out, do you know what I mean?”* (Interview IH15)

The quote elucidates the practical and pragmatic mind-set of the teacher in that any resource she

encounters, if it is not relevant to the science syllabus, then it is seen as a distraction that leads the learning away from the curriculum. This is a powerful statement and demonstrates the teachers almost ruthless sentiments when utilising any educational resource. If it does not meet their requirements, then it is irrelevant in their minds. This highlights the importance of a resource that is aligned with the curriculum and this was a key facet of the video hook design.

As is evidenced in section 7.3.1, the teachers in design cycle 2 readily adopted the video hook technology into the classes. This was distinctly different from design cycle 1 in which participants felt restricted by the ‘hook’ pedagogy. In accordance, the pedagogical changes had a dramatic impact upon student reaction to the hook. This will be fully articulated in the following section.

7.3.4 Unveiling Knowledge Gaps: The Development of the Student Impact Model

7.3.4.1 Introduction

Following the descriptions of the pedagogy utilised in design cycle 2, this section will illuminate the hook impact model. The overarching theme that became apparent in this phase is that the hooks provided a stimulus in tandem with the pedagogy to unveil a knowledge gap in the students’ mind. This provided the drive for exploratory behaviour in class which will be defined with regard to situational interest, engagement and attention.

The initial reaction of the students to the video was similar to the pilot phase. At first, when the video is played, the students sit up and pay attention as their interest is triggered. This is deemed to be inherent with the utilisation of video technology in class. The attentive reaction lasts for approximately 10 to 30 seconds. This reaction is based off the student interaction with the novel technology and not the video hook content. For a fuller and evidenced insight into this initial reaction and its theoretical justification please refer to Chapter 6.

In design cycle 2 however, the student impact is described as a ‘multi-layered’ reaction, emanating from a combination between the hook content and design along with applied pedagogies. The ‘impact’ as a construct, is distinguished from the students’ initial reaction of ‘attention’ to the video in both its intensity and duration. Research pertaining to hooks discusses the impact on students in terms of three separate constructs; attention, interest and engagement. The constructs and their interplay were assessed utilising observations (Renninger and Bachrach 2015) and teacher interviews. All three constructs were present in nine of the ten observations (one

purposive deviant case with an older exam based class was analysed), however, the overall reaction can be characterised by the hook impact model which encompasses the three constructs to varying degrees. The student impact will be explored presently through the development of the model which draws upon evidence-based classroom reactions to the hook videos and associated pedagogies. It should also be noted that when the student reaction is being discussed in the following sections, the evidence provided describes the reaction from the majority of students in the classes that were observed. As termed briefly in the pedagogy section, the emergent theme and reaction to the hook by students was a positive one centred around creating interest among other constructs. This will be explored presently.

7.3.4.2 Revealing Knowledge Gaps

“Take a student, place him in a situation of moderate uncertainty about some topic and get out of his way while he gets excited and attentive and directs his exploration to the source of his uncertainty. Moreover, research has demonstrated that he will enjoy his exploration and the accumulation of knowledge” (Day 1982, p. 19).

The first observable reaction to the video content by the student body that was recorded in nine of the observations and noted by eight of the teachers was one of disbelief, curiosity and interest. Students’ first reactions were “Wow!”, “Cool!”, “Yes!” and more commonly “What?”. These “What?” moments represented a positive engagement with the hook content (McCrorry 2011). A typical reaction by students during the video hooks is below;

Student A: *“What!?”*

Student B: *“No!”* (Observation ROD15)

The students level of disbelief when watching the hook and partaking in the teaching activities was readily observable in class and was also noted in teacher interviews;

Catherine: *“...like I heard one of the girls and I know she is extremely, extremely smart, she em, the bit about the Blu-Tak, she went ‘o my god, look at that’...”* (Interview IC15)

Evidence suggests that the video hook with the associated pedagogy displayed something that the students could not fully comprehend and this acted as a foundation for the generation of curiosity

driven interest. The hooks displayed phenomena that students wanted to know more about and this was evident in their reaction across nine of the ten classrooms.

Aisling: *“but I think that’s it, I think it’s the fact that it is not the result they are expecting so they, they might think the oil will float, but most think that maple syrup will as well because it looks kind of similar, [...] whereas when it doesn’t, they’re like, ‘why is that?’”* (Interview IA15)

Aisling: *“I mean they do see things sometimes and they will be like a no that’s not right or I don’t feel that’s the case...”* (Interview IA15)

Yvette: *“When they see something different then it really gets them to kind of like, why did that happen and to get them I suppose, yeah generate their interest in the topic and wanting to find out more, that did not happen the way I thought it was going to happen.”* (Interview IY15)

James: *“there’s ones there like, say the centre of gravity one, they didn’t believe that one worked.”* (Interview IJ15)

The teachers suggested that students displayed a high level of early disbelief, curiosity and interest when watching the hook. However, this reaction was maintained beyond the initial “What?” moments, as was evidenced by the students’ continued desire to perform the content of the hook. Students needed to ‘see it for themselves’ in order to satisfy their curiosity. Teacher interviews and classroom observations shed light on this theory;

Denise: *“Straight away after I had shown them that one because I said they like doing things, they were ‘Can we do this?’ ‘Can we do this?’ ‘Can we do this?’”* (Interview ID15)

Eva: *“centre of gravity was the other one that I used and I think the hammer and the meter stick and the that, that one, was the one I couldn’t show them (physically demonstrate) and they were like ‘whaaaaat (upset)?’”* (Interview IE215)

Emma: *“As I said, today, I was organised because the other two videos, I have shown, the minute they were done, they wanted to recreate the experiment and they had remembered every single detail. I couldn’t believe it...”* (Interview IE115)

As can be derived from the data above, the students wanted to recreate the hook and potentially prove that what they had seen was real. This is one of the desired outcomes of any hooking strategy as Reindeau (2013, p. 380) states “you are not looking for answers... you are trying to get the students so interested that they seek answers for themselves”. The data suggests that students were indeed seeking answers to questions that the hook and teaching strategy had provoked. It is posited by Arnone *et al.* (2011) that stimuli characterised by uncertainty can act as triggers for curiosity. Within the hook interventions, the ‘What?’ moments can be characterised by curiosity and this was the trigger for the students to seek competence in that subject area through exploratory behaviours (Arnone and Grabowski 1993, Jirout and Klahr 2012, Keller 1987a, Keller 1987b). Curiosity is described by Shenaar-Golan and Gutman (2013) as an ambiguity between new and previous knowledge, evoked through complexity, novelty and unfamiliarity. This is akin to a cognitive conflict and some of the teachers noted this reaction also;

Aisling: *“There is a result that they are not expecting, I think in their own heads, they think they know the answer before they see it.”*
(Interview IA15)

Yvette: *“They will kinda say, look it, you can see it there with your eyes, like, and its creating that conflict in their heads.”* (Interview IY15)

The quotes indicate that new information being revealed to the students by the hook. As such, there is the potential that an information gap is being revealed which drives the student curiosity. Curiosity as a condition, is one of discomfort due to an inadequacy of information (Arnone *et al.* 2011). Therefore, motivating exploration to remove what can be described in the students’ mind as an information gap (Berlyne 1966) due to aversive cognitive deviations (Boyle 1983) created by the teaching scenario. Theories of curiosity-driven exploratory behaviour succinctly describe the student reaction to the hook, as illustrated above. Berlyne (1966) was the first to coin the term ‘epistemic curiosity’ to describe such phenomena. Epistemic curiosity is the drive to acquire new knowledge with associated positive feelings through interest or to reduce an undesirable state of information deprivation (Litman *et al.* 2010). Berlyne’s (1954, 1966) work in the area of epistemic curiosity has formed the basis for the underlying information-gap mechanism behind the impact that hooks have on students. The information-gap has been discussed by numerous authors (Edelson and Joseph 2004, Jirout and Klahr 2012, Loewenstein 1994) and most recently advanced by Rotgans and Schmidt (2014) who opt to use the term knowledge deficit/gap instead of

information gap. They align their research of knowledge deficits in terms of situational interest. The authors compare the development of epistemic curiosity and the development of situational interest as being in parallel. That is, they are denoted the same construct and process (Kashdan and Silvia 2009). This expands on previous work by Arnone *et al.* (2011) who defined curiosity as a construct that is concomitant with both interest and engagement. The authors note that developing curiosity is often discussed in the literature as the primary way of triggering situational interest (Arnone *et al.* 2011) and this is comparable to what happened in 90% of classes observed in this phase. Rotgans and Schmidt (2014) delineate a model in which situational interest arises when there is a gap between what one knows and what one needs to know, referred to as a knowledge deficit/gap. A knowledge gap is triggered when an individual is in an environment where they are aware of new cognitive deviation in their own schema. The authors state that “If a precipitating event in the learning situation produces such awareness and therefore situational interest, the learner seeks additional knowledge about the topic until the gap is closed” (p. 5). The former quote neatly aligns with the student reaction in class upon witnessing a precipitating event, in this instance, the video hook. It is postulated by the researcher that the initial and maintained reaction to the video hooks came about due to the revelation of a knowledge gap in the students’ understanding of a particular topic. Often students expressed the knowledge gap through questions, wanting to replay the video or conduct the experiment for themselves. Such reactions will be explored in the following writing. However, they are indicative of situational interest which usually occurs when students report their excitement immediately or during a specific intervention (Palmer 2004) and this is evidenced on numerous occasion by the “What?” moments.

The hook and relevant pedagogy provided a suitable platform for triggering situational interest through ‘What?’ moments or what can also be determined as the creation of a knowledge gap. In accordance, the knowledge gap phenomenon observed also explains how situational interest was maintained for the duration of the class and beyond as it provided the condition that ensured the continuation of interest. The reaction of the students in this cycle was more so aligned with what was intended during hook video design. As discussed in chapter 3, the video hook design considered a discrepancy model at concept formation. Phenomena in the video were designed to be counter intuitive through discrepancy. Students initial reaction was that of disbelief with the generation of triggered/maintained interest and curiosity seeking behaviour. It is positioned by the researcher that two clear moments are present in the data, which include the aforementioned initial

“What?” moments exhibited by the students being parallel to the triggered phase of situational interest and the foundation for the exploratory driven behaviour or maintenance phase of situational interest. Hence, the model defining the impact on the students at this point is a two-stage model of situational interest development (Figure 7.4) based on a knowledge gap hypothesis.

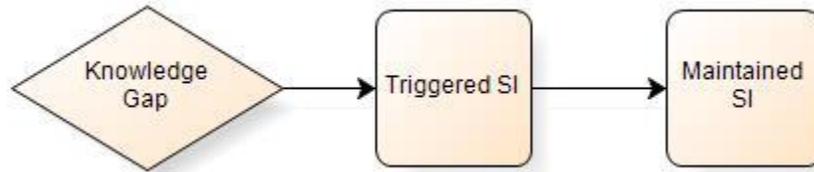


Figure 7.4: The triggering and maintenance phases of situational interest

The next section will further explore and examine the various elements of the triggered situational interest phase to build upon the two-stage model.

7.3.4.3 Phase 1: Triggered Situational Interest

The “triggering interest and supporting its development are likely to be essential to whether an engagement intervention will have the power to change behaviour.” (Renninger and Bachrach 2015, p. 59). The triggered phase of situational interest during this intervention is the keystone for longer-term impacts. The chronological and visible aspects of the triggered phase will be demarcated presently.

As noted in the previous section, the triggered situational interest phase can be characterised by the ‘What?’ moments. The researcher posits that these “What?” moments represent a positive emotional engagement with the video content (McCroy 2011) akin to ‘yes’ moments (Muldner *et al.* 2010). In a study by Muldner *et al.* (2010), ‘yes’ moments were observed when students expressed excitement or pleasure while engaged in a lesson. The ‘yes’ moment was a positive affirmation of interest that in turn improved performance and cognitive function (Muldner *et al.* 2010). In this research, the emotions being displayed during ‘What?’ moments were curiosity and interest. More specifically a triggered interest that encompassed increased attention (Linnenbrink-Garcia *et al.* 2010) both during and post the video hook. Thus, the triggered phase can be characterised by emotional engagement and attention. This is in line with Rotgans and Schmidt (2011) who state that situational interest is an immediate affective response that

focuses one's attention on a task. Renninger and Bachrach (2015) expand on this and claim that both interest and engagement can be triggered by something catching the attention of learners. The triggering of interest can establish the initiation of engagement (Magner *et al.* 2014, Peters *et al.* 2009, Renninger and Bachrach 2015). Employing the research data, the following sections will examine the relationship between firstly, emotional engagement and secondly attention with the triggered phase of situational interest.

The reaction of the students to the hook content was readily observable in class by both the researcher and teachers. Changes in student demeanour, facial expression and body language occurred instantaneously as a number of the observation reports recorded.

Student A: *"can we do that?"*

Student B: *"that's cool"* (Observation ROH15)

Another group of students reacted in the following way to the atmospheric pressure hook.

Student A: *"Is that just cold water?"*

Student B: *"Whoa!"*

Student C: *"What?"* (Observation ROJ15)

The following excerpt from an observation demonstrates how the reaction can encompass both physical as well as verbal signals during the triggered phase.

The students watch the second hook on atmospheric pressure. Some of the students' jump when the can gets crushed in the video. Some say "class".

(Observation ROR15)

The student in the excerpt above uses the word 'class', a colloquialism that can be translated to 'brilliant'. A range of emotions may have been felt and displayed by the students at the expressive "What?" moment (McCrary 2011), however, the strongest emotions present were that of curiosity and triggered interest. Observational and teacher interview data suggests that the former constructs represent an emotional engagement with the content. Emotional engagement refers to students' affective reactions such as anxiety, interest, happiness or enjoyment (Hampden-Thompson and Bennett 2013). Per McCrary (2011), there is a wide range of positive emotions that teachers can foster through their teaching. Curiosity, anticipation, uncertainty, surprise, understanding, wonder and amazement are components of good teaching that give pupils an emotional reward linked to

the topic that should augment levels of engagement and interest (McCrorry 2011). According to Klassen and Klassen (2014, p. 135) “Educational interest arises from an emotional response to certain kinds of stimuli in the learning episode and consists of increased and persistent attention to the interesting situation accompanied by increased cognitive activity and the desire to re-engage”. This quote summarises the triggered reaction from the students as similar instances occurred across nine of the ten classrooms visited. Indeed, many authors agree with the description of interest as a type of emotional engagement (Arnone *et al.* 2011, Bergin 1999, Chen and Darst 2002, Fredricks *et al.* 2004, Fredricks *et al.* 2005, Hidi and Harackiewicz 2000, Linvill 2014, Renninger and Bachrach 2015, Sinatra *et al.* 2015). Rotgans and Schmidt (2011) describe situational interest as an affective or emotional response to instruction. Subramaniam (2009) denotes situational interest as an affective reaction triggered by an object. This indicates that interest can be defined as a form of emotional engagement and in this study, emotional engagement is deemed to be strongly present in the triggered phase of situational interest.

Pertaining to curiosity, Arnone *et al.* (2011) describes curiosity as a construct that incorporates both interest and engagement with Krapp (2007) indicating that the first occurrence of triggered situational interest is characterised by curiosity. According to Luce and His (2015, p. 73) “The learner can express curiosity as fleeting observations of wonderment and noticing inconsistencies or finding novelty in an object or through activity”. Loewenstein (1994) agrees with such views and describes curiosity as a deprivation based emotion that occurs when an individual recognises a gap in their knowledge. Within the students’ ‘fleeting observations’ of the video hook, they were drawn into attempting to figure out an unusual phenomenon as can be noted above with students asking questions such as “Is that just cold water?” or “Can we do that?” as the video is being played. The student had an intense curiosity to acquire an understanding of what they had just observed as per the knowledge gap theory. Teachers expressed similar sentiments in terms of an immediate emotional engagement with the content, the overarching emotions being curiosity and interest.

Aisling: *“they loved the density tower, o my god, they absolutely loved it, they thought it was really cool, and as I said they were kinda like, we want to do that”*. (Interview IA15)

Emma: “a video is at face value, a video and whatever they get out of it [...] I just didn’t expect them to be so into it”. (Interview IE115)

The two teachers’ language and sentiments indicate that the students’ reaction was plain to see, although somewhat unexpected as they had not had similar experiences with other videos.

At this point, the researcher is advocating that the triggered situational interest phase is characterised by an instantaneous and immediate emotional engagement with the content. Figure 7.5 advances the first model by incorporating emotional engagement as the first observable construct among the student body when the hook is effectively integrated into instruction.

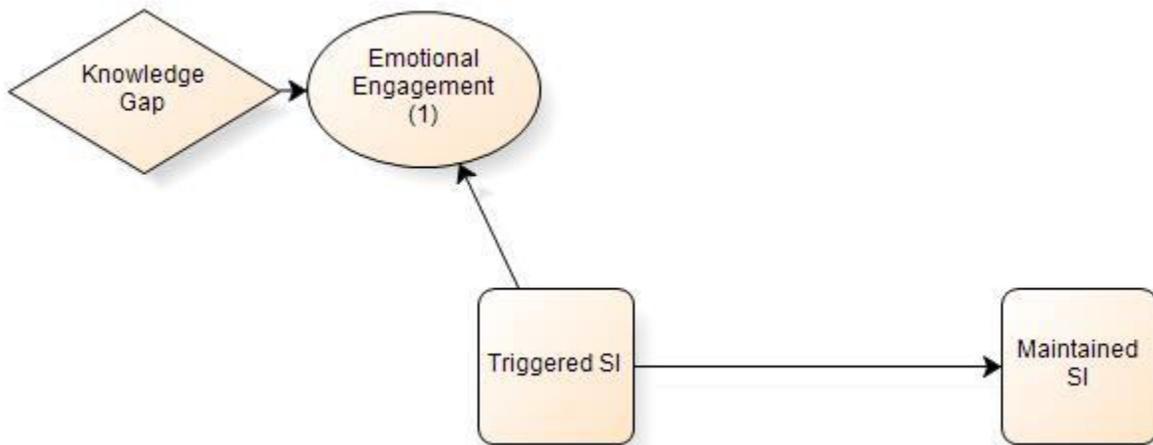


Figure 7.5: The model of situational interest with emotional engagement as a key feature of the triggered phase

From a temporal perspective, the next noticeable trait of the triggered interest phase which directly followed the ‘What?’ moment was a heightened state of attention from the students as they continued to interact with the hook content. Similar to other aspects of the triggered phase, this was something that visibly manifested itself during observations.

Many of the students sit up during the video, especially the ones on the back. (Observation ROR15)

The students are really paying attention during the video, they are sitting up in their chairs and they seem to be very interested. The students are answering the questions that are placed on the screen and in the video, they sometimes look at each other and attempt to explain the answers to each other. (Observation ROC15)

The data shows how students sat up in their seats and moved their heads in an attempt get a better view of the screen once their interest had been triggered. This was not the same as their initial reaction to the start of the video which is typified by initial attention and quiet concentration. All video hook interventions up to this point both in design cycle 1 and 2 have had the initial quiet reaction, however, in design cycle 2, the reaction from the majority of interventions and students further evolved into triggered situational interest as described in the observational accounts above. When teachers were asked about the student reaction in terms of interest, attention and engagement, they would talk about attention more so than the other two constructs. This following quote demonstrates this but also shows how teachers would in some instances define attention, interest and engagement differently with respect to the literature and often denote them as the same thing. This occurred in five of the ten interviews and determining their intent required stringent inquiry and reference to the pertinent literature. In this instance, Richard classifies the entire student reaction in terms of attention.

Richard: *“Definitely attention and engagement 100% that definitely in both cases and immediately afterwards you noticed that they were, they were, they got into the activity a lot quicker than they would have usually you know they would spend a bit of time and be half a chat and you would have a few minutes gone before everybody would be settled to it, I felt that they kind of in terms I think attention and engagement are almost the same in a lot of things when they are doing something so I definitely would notice those two.”* (Interview IR15)

Indeed, the attentive student response was one of the most common reactions noted by eight of the teacher participants. Theoretically, such instances can also be defined as indicator of triggered student interest (Linnenbrink-Garcia *et al.* 2010). This is something that has been noted in the theoretical framework chapter of this thesis in which grabbing attention is defined as one and the same as triggered interest. This assumption is based on work by Linnenbrink-Garcia *et al.* (2010). Expanding on this, Flowerday and Shell (2015, p. 135) state that situational interest can be “instrumental in catching attention”. A number of other authors agree on the definitive relationship between attention and interest (Ainley *et al.* 2002, Hidi *et al.* 2004, Mazer 2013, Palmer 2009, Peters *et al.* 2009). Attention involves heightening the attentive responses of individuals due to their environment and refers directly to the initiation of interest (Linnenbrink-Garcia *et al.* 2010). Head and bodily movements (as noted above) are typical of attention and interest as it aids tracking

of both objects and sounds (Silvia 2008), something that is omnipresent in video. Interest facilitates attention and alertness so that learning is more focused and pupils may observe something they otherwise would have missed (Bergin 1999, Kerger *et al.* 2011, Schraw *et al.* 2001) and this is something students were actively doing in class. Furthermore, this type of student behaviour aligns with the knowledge gap model as students were trying to actively figure out new phenomena displayed by the hooks, evidenced through their physical and attentive behaviour.

In terms of the hook impact model, attention can now be added as the chronologically second visible attribute directly following the emotional engagement of “What?” moments. The emotional engagement expressed by the students gives way to attention as they calm down from their initial reaction. This is not to say that students were not paying attention when emotionally engaged, rather, this is the observable manifestation of the reaction across classrooms. The various aspects of the phase were readily observed by the researcher during the interventions and are demonstrated in Figure 7.6.

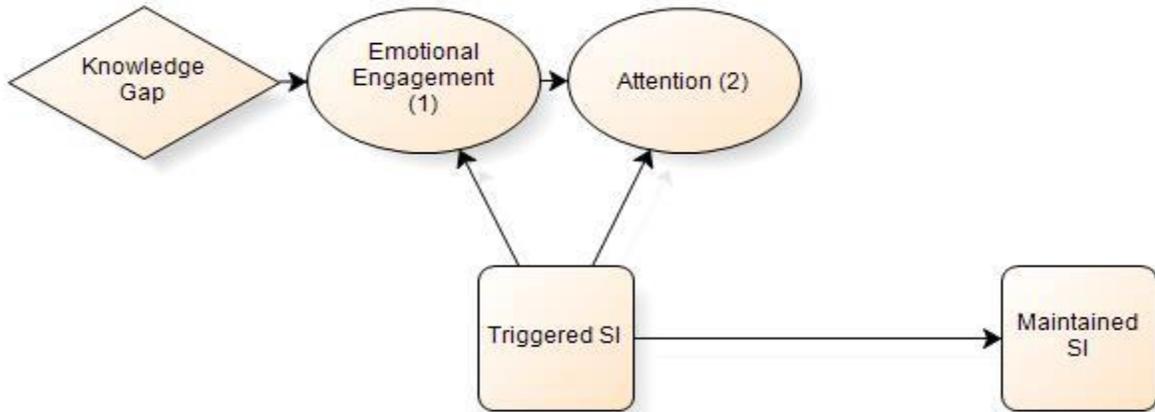


Figure 7.6: Model of situational interest development with the two stages of triggered situational interest, emotional engagement and attention

Both emotional engagement and attention characterise the triggered situational interest phase. Rotgans and Schmidt (2014) state that students who become emotionally engaged through curiosity or any other emotion will put in the effort to learn difficult content. That is, the triggered foundation of situational interest should feed into the maintained situational interest phase. In the present study, student interest was maintained beyond the length of the video and the students’

triggered reaction. The maintained situational interest phase of the student reaction will be fully established in the following segment.

7.3.4.4 Phase 2: Maintained Situational Interest

Framing the student impact through the knowledge gap theory in terms of situational interest indicates that the former triggered phase, revealed a knowledge gap with an associated visible reaction from students. However, the impact of the knowledge gap on the students also lead to the manifestation of maintained situational interest. The rationale behind this theory will be justified presently.

It is argued by the researcher that students in the study demonstrated knowledge seeking behaviours such as wanting to recreate the hook or re-watch the hook in order to close their knowledge gaps. The data indicates that various behaviours represent the maintained situational interest phase. Building upon the triggered reaction, students' interest was upheld and led to some of the most evidenced and noticeable reactions. The data reveals that students were extremely interested in the phenomena within the hook videos, which sometimes extended for the rest of class, sometimes for longer. As noted previously, one of the most common sentiments expressed by the students was "Can we do that?". This was an enduring disposition throughout observations, however, nine of the teacher interviews showed evidence that the maintained interest phase, lasted beyond the class with students referencing the video in both homework and tests.

Denise: *"Even then for homework it was give an example of friction? and when I was going around looking at the copies some of them had said 'if you put a knife into rice' (content in hook)." (Interview ID15)*

Aisling: *"I mean the fact that they can actually relate the stuff they saw in the videos to a test that they did a week later, I mean, I mean that is showing a long-term impact and actually I could see based on their answers, they were referencing the video." (Interview IA15)*

Another teacher described a situation in which a student went home and built one of the props from the video so the class could recreate the hook the following day.

Emma: *"well I had one massive impact and it was the energy conversion one, the weakest student in the class and eh, he was the person who came up with the can [...] the next day and so, it has given him massive, I suppose the effect it had on him was massive*

Chapter 7: Design Cycle 2

because the rest of them know he's very weak because it's quite a strong class and he's the weakest. He has, he is better at practical work and he's so quiet and there he was coming in with the object that everyone else could use then.” (Interview IA215)

It is argued that due to the students taking their knowledge from the hook video into aspects of learning outside of the class and into other classes, is indicative of a maintained situational interest (Hidi and Renninger 2006) in science.

Other evidence advocates a maintenance of interest through a cognitive engagement with the content. Similar to how an emotional response characterised the triggering phase, a cognitive response may define the maintained. Cognitive engagement can be characterised as a psychological state in which students exert extra mental effort and persistence to understand a topic over a period of time. It can be further operationalised by interactions with teachers in class (Rotgans and Schmidt 2011a). Cognitive engagement refers to the extent students expend mental effort when they encounter learning tasks. It is often represented by persistence (Fredricks *et al.* 2004, Hidi and Renninger 2006, Zhu *et al.* 2009). The first piece of evidence to suggest how students were cognitively engaged was that they demonstrated a persistent desire to close their knowledge gap through the acquisition of more information. For some, this was to ask can they perform the hook, for others it was through asking questions in class.

Richard: *“...the level of the questions that they asked were much better than other lessons, I think the way that they, the way they worded their questions, maybe that they were just thinking about things more and that would be not at all reflective of what you would usually get back you know they had kind of maybe worded it and I dunno, maybe that, maybe the video had an influence on that as well or maybe that they were just more settled and they were actually thinking properly about it.” (Interview IR15)*

Catherine: *“what was even more interesting is what came from it (the hook), the questions that they had, like ‘what if?’”.* (Interview IC15)

Researcher observations recorded a similar cognitive engagement with the content;

The students are asking excellent questions and this was also noted by the teacher in the interview, how the hook seemed to make them ask better questions than

Chapter 7: Design Cycle 2

they would usually ask. The questions were derived from the hook and were about forces. (Observation ROR15)

The second piece of evidence to suggest that the majority of students were cognitively engaged was that they could remember almost every aspect of the video. As one teacher participant noted earlier, the students remembered “every single detail” of the hooks, as can be seen in the data below. This was a surprise to teacher participants and the researcher.

Emma: *“I went through it (the hook) and they remembered every detail. They spotted even things like there was hot water put in, into the can, down to they noticed that it was one third of the volume of the can that was put in.”* (Interview IE115)

Emma: *“They had a high level of knowledge and they were able to spot it all and they were able to apply other knowledge to the video so it was consolidating all their knowledge.”* (Interview IE115)

In the instance above, the students were explaining all the various aspects of the experiment they had observed in the video. Perhaps due to the hooks professional production level and curricular design. The hooks are based on the Irish syllabus and have a curricular feel as they have the same editing, music, introduction and credits. Once interested, they ‘soaked up’ the information and imparted a high level of credibility onto the video hooks as can be derived from the following data;

Teacher: *“Why is it called a tuning fork?”*

Student: *“Because it said so in the video”* (Observation ROE115)

As can be seen above, some students had a very high regard for the video. The student in question had never come across the term ‘tuning fork’ before, but still remembered it from the video. Below, a researcher reflection corroborates this theory.

One thing I couldn't believe is how much information the student extracted from the video. They answered questions about the video more efficiently and faster than any other questions that were asked during class. The students know every fact about the video and I found it very surprising. For example, they remember all of the objects dropped into the density tower such as the ping pong ball and the nail. (Reflection ORC15)

This data substantiates that the students’ cognitive working memory was effective at comprehending and retrieving aspects the video (De Jong 2010, Mayer and Moreno 2003). Taking

into account both the higher level questions and the students' memory retrieval, the maintained situational interest phase can be characterised by augmented cognitive efforts (Hidi 2006) and cognitive persistence. Hence, the model can be further progressed at this stage (Figure 7.7).

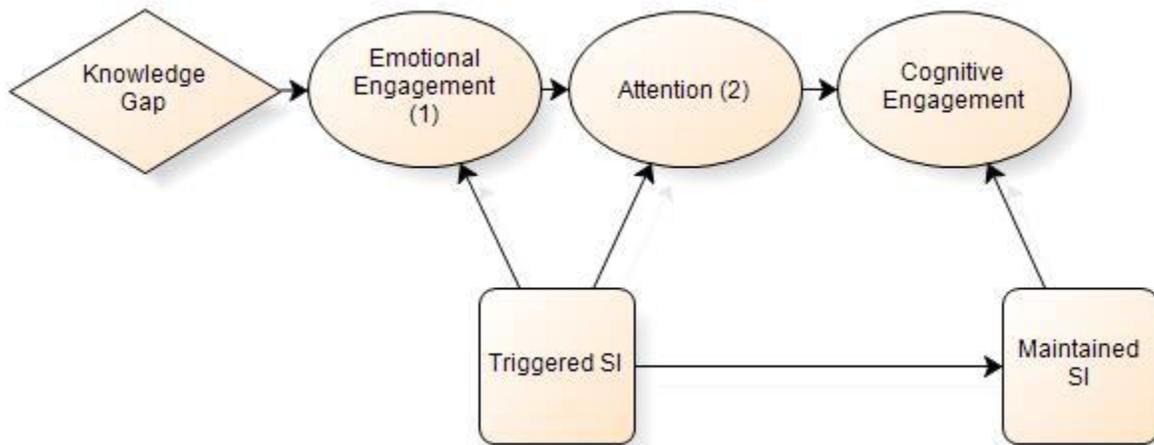


Figure 7.7: Model of triggered and maintained situational interest with cognitive engagement

The final piece of evidence that suggests student interest was maintained is derived from Mitchell's (1993) study in which the author examined sources of hold facets (maintenance facets) of interest. One of the maintenance facets derived by Mitchell (1993) was that of meaningfulness. That is, the content was personally relevant to the student and meaningful at that moment in their lives (Mitchell 1993). Interest is nurtured through meaningful tasks and/or personal involvement (Hidi and Renniger 2006). Mitchell (1993) states that meaning in learning is critical for maintaining interest. It is also suggested by other authors (Linnenbrink-Garcia *et al.* 2010, Magner *et al.* 2014) that maintained situational interest is a more involved form of interest whereby "individuals begin to forge a meaningful connection with the content of the material and realise its deeper significance" (Linnenbrink-Garcia *et al.* 2010, p. 2). It is positioned by the researcher that the combination of pedagogy and hook design operated in tandem to create a meaningful learning scenario which led to the development of maintained interest. The data supports this theory.

Denise: *"I know at one point in that class anyway when I was walking around the class that you were in, I overheard one of them saying, 'no stop, this is us being real scientists now', which is very strange to hear from that class..."*. (Interview ID15)

In this extract, it is obvious that the students were very committed to their work and self-identified as ‘real scientists’, with respect to the extended inquiry lesson following the hook video. The word ‘now’ also indicates that this learning environment was different and was potentially more meaningful than other environments the students had been in previously. Thus, the hook based learning environment may have brought about this change. Even the teacher comments on how that type of remark was strange for that class. Researcher reflections and observations contribute to this argument.

Yet, they are still working hard trying to do it (perform the experiment) in class [...] they simply want to achieve a goal they have observed and prove it to themselves and the rest of the class. (Observation OD15)

In addition, everyone was able to make a prediction based upon their intuitive knowledge. Students let out shouts of “ya” and “yes” as they were proven correct. (Reflection ORA15)

The first extract demonstrates the persistence of the students in a task they find meaningful, which also links back to the persistence of cognitive engagement. The latter extract exhibits how students are invested in the hook related pedagogy. They are not passive learners; they are actively invested in the learning process.

As can be derived from the data, meaningfulness is a key component of the maintained phase and it may be the case that the knowledge gap established by the pedagogy and hook, established meaningful learning conditions in the learners’ mind. At this point, the last observable attribute of the proto-theoretical student impact model, meaningfulness, can be added (Figure 7.8).

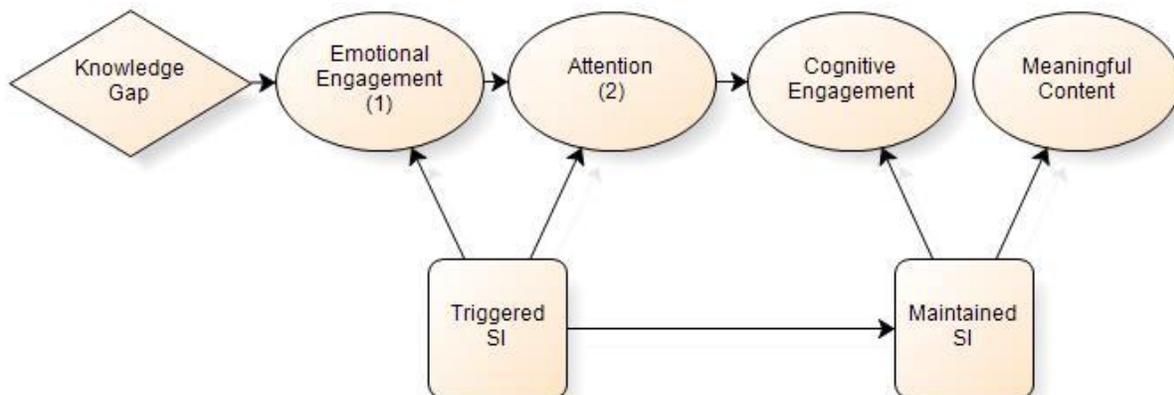


Figure 7.8: Student impact model for design cycle 2

The finalised model will be further discussed in the next section.

7.3.4.5 Theoretical Positions and the Student Impact Model

The fully developed hook impact model (Figure 7.8) represents the holistic effect of the hook videos on the student body when effectively integrated into classroom instruction. It has been developed based upon two phases of research within a DBR framework and will be subject to further examination in the next research phase. At this point, the various components of the model are clearly delineated, however, it should be noted that there is potential overlap between the constructs from a theoretical grounding.

Krapp (2002, p. 388) describes situational interest as a psychological state that “involves focused attention, increased cognitive functioning, persistence and affective involvement”. As a definition, it describes every aspect of the model. Other research describes situational interest as a disposition that crosses the boundary between the cognitive and emotional domains (Hidi and Harackiewicz 2000, Renninger and Bachrach 2015). Hidi and Renninger (2006) put forward that early phases of interest development (situational interest) consist of focused attention and positive feeling. This refers to an altering of the physiological state that is co-ordinated in short term affective and cognitive processing (Hidi and Renninger 2006). These theoretical positions lend credence to the overlap between engagement and interest as represented by the model. Moreover, McCrory (2011) posits that situational interest contains phases of both affective and cognitive engagement, which was also present in this research.

In terms of engagement, numerous authors discuss the overlap between emotional, cognitive and behavioural engagement (Fredricks *et al.* 2004, Li and Lerner 2013). Sinatra *et al.* (2015) puts forward the argument that the three engagement constructs, emotional, cognitive and behavioural cannot be effectively distinguished as there is so much overlap between them. Engagement as such, is a meta definition with the unification of three constructs that are inadequate as definitions of engagement on their own. This conceptualisation of engagement is not agreed upon by all authors, however, the tripartite ideology has approached the vanguard of current engagement research. (Li and Lerner 2013). Within the model, emotional and cognitive engagement are conceptualised as separate entities, however, there may be overlap between the constructs in reality. In addition, it may be possible to denote that behavioural engagement was present in class, however, the model has two distinct phases and within those phases emotional

and cognitive engagement provide the best summary of what was observed. In accordance, the model is specifically designed to be simple and of use to educators, hence, another observer would recognise the emotional and cognitive engagement aspects as two distinct phases. The model acknowledges such links, however, also notes a temporal aspect to the emotional and cognitive factors present. Chronologically, emotional components of the model characterised early phases, while cognitive components are present more so in the latter stages. However, it is positioned by Ainley and Ainley (2011, p. 53) that such a “temporal duration is critical to the identification of situational interest”. Hence further strengthening the theoretical links between interest and engagement identified within this study. Yet, the model has been created so that it is of practical usage. Teachers can apply the model to their own classrooms and observe if the various aspects of the model are present when they employ hooks in their own teaching.

When examining the student impact, it is in stark contrast to the limited impact of the hooks in the pilot phase. The driving force behind this change must be accredited to the pedagogy developed by the teacher participants. The instructional methods created worked in concert with the hook design and the video format, and each tailored to the individual diverse classroom environments. A range of teaching methods were utilised with some key communal strategies and themes. As noted previously, the open-ended design of the hooks allowed for the varied pedagogical approach. However, the observed student impact, can also be linked to various other aspects of the hook design. This will be elaborated upon currently.

7.3.5 Design and Pedagogy enabling the Student Impact

When contrasting the first two design cycles of this study, it becomes apparent that the video hooks should not be an isolated event within instruction. Indeed, the incorporation of the hooks into the fabric of authentic educational settings has enabled the design elements within the videos to flourish. Further examination of the data enables an insight into how the design features in the physics video hooks can be directly linked to phenomena observed. The following segment will elucidate this idea by linking the design elements of question and discrepancy respectively to the hook impact model by investigating theoretical positions and research evidence.

7.3.5.1 Questioning Design Element

The questioning design element may have been key in the development of cognitive engagement among the students. It was previously noted how the students would attempt to answer the

questions verbally as the video was playing. The questions guided the students through the video and students felt the need to answer the questions. Eva noted such a reaction in class;

Eva: *“Well I’m surprised as well at how much, I suppose, the, the draw that surprised me that would, how much that got them thinking, because I heard the girls going ‘no, its chemical’ and they would be girls that wouldn’t normally like get involved [...] so the fact that they do like the (videos), you know the value from they talking to each other about is so much more valuable than anything I say from the front...”* (Interview IE215)

This summarises the student reaction which was readily noticed by the teachers. An example of the questioning strategy is in the centre of gravity video which asks at 1:14;

“Do you think this experiment would still work with a metre stick and a sledgehammer?”

The question provided a guide for the teacher and enabled the aforementioned segmentation pedagogies through natural pausing points in the content. The question allows the teacher to ask students to predict Yes/No answers and then explain themselves. One of the teachers summarised the benefits of having questions in the video design.

Richard: *“...myself I just played it and it left them with the question, I didn’t have to ask the question, the idea was there for them you know and that they were thinking there, I had a feeling when I was watching them they were thinking about the question before the question was asked at the end you know and I think that that’s the really good thing that it stimulated them to think about what’s happening in the video and why it’s happening before anybody asks them that.”* (Interview IR15)

The data demonstrates how the video design fed into the pedagogy and vice versa. However, it is the position of the researcher that the questioning design element aided the longer term cognitive impact of the hook. It guided students’ curiosity toward their knowledge gap and the areas in which they should focus for learning. The teachers seemingly recognised this and worked with the questions in guiding the students through the learning cycle.

7.3.5.2 Discrepancy Design Element

As noted, the questioning design element aligned with the cognitive engagement, however, the design feature that aligns with and potentially contributed the most to the hook impact model was the discrepancy design strategy. Every video attempts to present a scientific anomaly requiring investigation. This technique, embedded into the videos, combined with the lack of explanation and narrative allowed for the development of the “What?” moments. Discrepant events within instruction are noted by a number of authors as a method to elicit interest from students (Bergin 1999, Thornton and Sokoloff 1998). This is where an educator presents a topic that deliberately utilises misconception to reveal a knowledge gap, augment interest and consolidate learning. As the students watched the hook, a cognitive reappraisal occurred in which constructs of knowledge that pupils have built, based on previous experience and instruction, become conflicted. In short, when confronted with the video hook, and the embedded discrepant anomaly, the pupil’s reaction was that of the former hook impact model. Hence, it is a logical supposition that the discrepant design strategy played a key role in determining the knowledge gap reaction. This was obvious when observing students during the energy conversion hook video which asked, “how do you convert chemical energy into kinetic energy?” Upon seeing how the video answers the former question, students expressed disbelief and wanted to try it for themselves. Within the hook, there is a demonstration the conversion process of chemical energy (blowtorch) into kinetic energy in the simple steam engine. This was the moment the entire video was building. The revelation of the discrepant event in the video is the point when students express “What?” moments. The ‘seeing is believing’ reaction observed in the data was the exact aim of the discrepancy strategy.

This is another example of how the pedagogy developed by the teachers worked in tandem with the hook design. Within the class in which this hook was played, students were asked using the relevant equipment in the hook to turn chemical energy into kinetic. Therefore, prior to watching the hook, they had developed their own conceptions/misconceptions of the solution in their minds. When the real solution was played in the class through the hook what they observed and what they expected were two different things, thus enabling the revelation of a knowledge gap. The instructional strategy employed by the teacher ensured that the students had a vested interest in the hook, but also that the discrepant event was a focal point of the lesson (Observation ROE215).

When designing the physics video hooks, the intention was to create effects or visuals that look impossible or implausible. Such a technique presents a student with a gap in their knowledge that has the potential to spark interest (Bergin 1999, Edelson and Joseph 2004, Rotgans and Schmidt 2011c). Indeed, the former sentence summarises how the student reaction could be delineated from the hook design. As noted above, the agent of change however, within this phase 2 of this research was the use of appropriate pedagogy. Teachers also ‘scaffolded’ the pedagogy around the discrepancy in the video, through segmentation and inquiry based learning. Thus, the intertwined nature of the design with pedagogy created the desired hook impact. As evident from the diverse pedagogies employed by the teachers (table 7.2), prior knowledge plays a key role in students recognising a discrepant event. The role of prior knowledge in this phase of research will be fully elaborated upon in the next section.

7.3.6 Prior Knowledge as the Anchor throughout Interventions

7.3.6.1 Introduction

With regard to the emergent themes in this study, the most unexpected was that prior knowledge would be the anchor (Schwartz and Hartman 2007) that enabled the successful implementation of the hooks in design cycle 2. As noted, during the inception of the video hook design, an explicit attempt was made to display discrepant scientific phenomena. With this, a comparison can be made between magic, discrepancy involving a trick, and the videos. Take for example a simple card trick. Card tricks draw in the viewer through an anomaly, something that isn’t intuitive and is difficult to figure out. However, one’s interest in the card trick is dependent on prior knowledge. Everyone who observes a card trick has seen and/or played with cards in the past. Thus, it is easy to recognise an anomaly when the magician finds a card they should not. Now imagine a situation in which the viewer of the trick has no experience with playing cards. They won’t find the magic interesting because they do not have the relevant knowledge of playing cards to recognise the anomaly. In fact, they will most likely find the entire experience confusing. This analogy justifies why the student reaction between the phases was so disparate. In design cycle 1, students lacked prior knowledge, whereas in design cycle 2, all the teachers developed prior knowledge through their respective instructional strategies. Theoretical positions state that the difference between confusion and interest is grounded in prior knowledge and comprehension (Tapola *et al.* 2013, Silvia 2008). This theme will be discussed presently.

7.3.6.2 Development of Prior Knowledge

The most common observation in terms of teaching throughout this phase of the study was that in every class the teacher spent a minimum of a quarter of the class eliciting the students' prior knowledge on the topic. Teachers attempted to build up a conceptual map in the student mind around the subject. Some participants referred to this as running knowledge or developing experiential knowledge. Often this was conducted using open and closed questions. Teachers would ask the students questions about the previous class and revise the key words and terms for that chapter as follows;

Teacher: *"What is opaque?", "Luke?"*

Luke: *"You can't see through it"*

Teacher: *"Are you confident in your answer"?* (Observation ROB15)

Generally, the initial teaching focus was on developing a level of conceptual understanding among the students before the hook and associated teaching activity. The timing of the lessons was also a factor as in the current phase, the hooks were used mid-topic and in the middle of the lesson, which is in stark contrast to the pilot phase in which the hook was used as an introduction to the topic and the lesson.

The researcher was first alerted to the issue of prior knowledge when one of the teachers noticed a difference between how stronger and weaker students rated the video hooks.

Researcher: *"Describe the impact if any that the hook videos had on your students?"*

Bill: *"em I suppose, what I do with them when I do show, when I show a video or a game or some piece of technology that I bring into the class, I do ask for feedback from it, the particular hook that we did was the sound one, the students' scored, the way they scored it as particularly interesting, the stronger students in the class, scored it eight to nine out of ten, right in terms of interest, enjoyment, I suppose the test will tell whether they get something out of it, the weaker students' scored it poorly."*

Researcher: *"Ok"*

Bill: *"Between five and six, alright"*

Researcher: *"Ok, why do you think that is or?"*

Chapter 7: Design Cycle 2

Bill: *“I think because they, they, I think it’s because they struggle with the physics and science.”*

Researcher: *“ok, so they were looking at the video and they weren’t...”*

Bill: *“...they weren’t picking up anything from it.”* (Interview IB15)

Seven other teachers agreed with this by making comments such as;

Eva: *“I think that prior knowledge was completely necessary for that video to work.”* (Interview IE215)

The account from the first interview details how the weaker student could not understand the concept in the video, whereas the stronger student could. The differentiator between the two groups was their level of knowledge in relation to the sound hook they were shown. The sound hook demonstrates how a tuning fork’s vibration can be used to make water splash out a beaker or paint a container. The premise is that the vibration, not only produces sound, but also a strong force. Take for example the stronger student, who observes the video and sees the tuning fork being used in a new context and expresses interest as this is something novel to them. Conversely, the weaker student watches the same video and finds it confusing as they have never seen a tuning fork and/or have no idea of its application in terms of sound or vibrating forces. Previous to watching one of the video hooks, the students require the correct and appropriate knowledge to cognitively navigate the video. The stark distinction between confusion and interest summarises the first two phases of the study. According to Silvia (2008), there is a fine line between confusion and interest that hinges on comprehension. The author states that students must have the knowledge and skills to deal with a learning ‘event’. A new novel event must be understandable so that the viewer can comprehend it as interesting. Silvia (2008) gives the example of students in an art museum. Some students find the work interesting because the work is new and novel, but without a knowledge of the artists, themes and motivations, they will generally find it meaningless. They do not know or have enough prior knowledge of the art to fully appreciate it. Hence, there is a ‘see-saw’ effect in terms of interest and confusion with relevant and prior knowledge being the determinant. The author states “New and comprehensible works are interesting; new and incomprehensible things are confusing” (p. 58). Novelty requires comprehension as understanding is the difference between interest and confusion (Silvia 2008). The trap, as noted by Klassen and Klassen (2014) is designing resources for interest and originality to the exclusion of familiarity. Novelty type features work in tension with comprehension and this could in part explain why the hooks within the pilot study caused

confusion as opposed to interest. The hooks may have represented novel stimuli, but without the relevant prior knowledge, they were incomprehensible to the student body. Students could not comprehend the videos, when presented in an isolated context. When used at the start of a topic and class, they lacked the pertinent knowledge and the videos caused confusion. However, when used mid-topic and mid-class, the teacher took time to set the context and build student comprehension of the concept. Hence, the students could recognise the novelty of the video, but also interpret the science as their prior knowledge anchored the video hooks in a steadfast manner within the lesson.

Prior knowledge caused an oscillation between the design cycles. In design cycle 2, students moved from confusion to interest. The constructs may seem disparate, but Silvia (2008) notes how the difference between the two pivots on comprehension and understanding. This is further reinforced by authors in the area of educational technology, who state that prior knowledge allows learners to decide what information is important in multimedia and how to organise it into their cognitive schema. Low prior knowledge learners have a harder time than high prior knowledge learners with meaningful learning tasks with the associated imposition of heavy working memory loads (Magner *et al.* 2014). Indeed, it was found that an open-ended design in a computer simulation may not be helpful for students with a novice chemistry background (Liu *et al.* 2008). The hooks embody the open-ended design approach, however, our target audience (11 – 14) may be novice learners in scientific realms. Hence, the importance of prior knowledge to the study.

Prior knowledge and its relationship to the development of interest is something that is widely discussed in literature, particularly in terms of the relationship between familiarity and novelty (Goldman *et al.* 2014, Magner *et al.* 2014, McCrory 2011, Schraw and Lehman 2001, Schwartz and Hartman 2007). According to Tapola *et al.* (2013, p. 3);

“The positive effect of prior knowledge on interest arousal and subsequent performance has been attributed to heightened attention towards familiar content and to being able to link the presented material to existing knowledge. Conversely, weaker prior knowledge may lead to superficial and less engaging cognitive activity due to the structurally incoherent or fragmented domain knowledge”.

The quote proposes that a moderate level of prior knowledge as opposed to low or high, leads to the development of interest. This theoretical standing is not new as Piaget (1952, p. 68), was the first to advocate an inverted U shaped theory of interest and curiosity in which “the subject looks neither at what is too familiar, because he is in a way surfeited with it, nor at what is too new, because this does not correspond to anything in his [schemes]”. Kintsch (1980) utilised a U shaped function to describe the relationship between interest and prior knowledge, that states low and high level prior knowledge learners on the extremes of the function demonstrate low levels of interest. Moderate levels of knowledge, should however, lead to the development of interest. Researchers are still unsure, how much prior knowledge is optimal, there is widespread agreement that moderate levels of knowledge augment interest (Litman *et al.* 2005, Schraw *et al.* 2001). Hence, it is put forward by the researcher that the pedagogy employed by the teachers gave students a moderate level of prior knowledge and concomitantly an appropriate level of comprehension in terms of recognising the ‘interestingness’ of the video hooks. For the sake of graphical representation, an adapted version of the inverted U shape model is presented in Figure 7.9 in which a parabolic graph is illustrated.

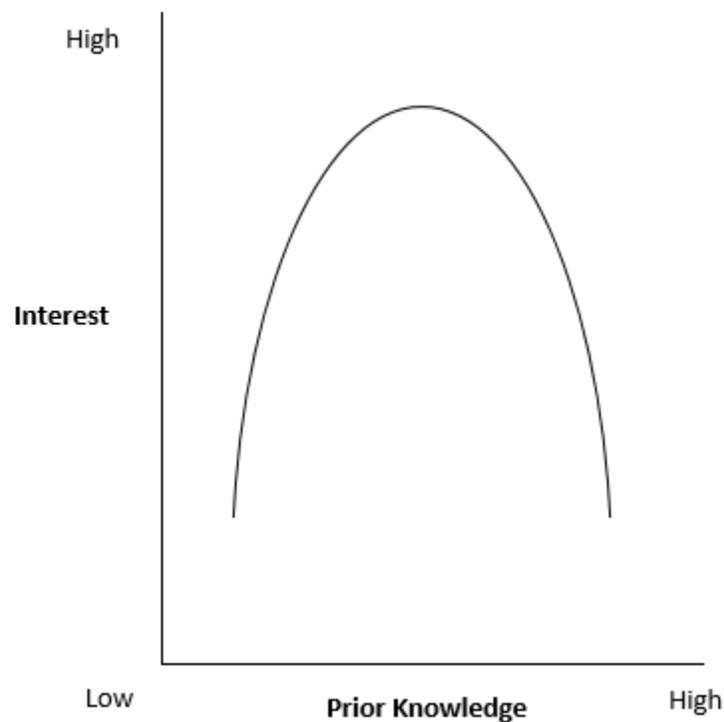


Figure 7.9: Adapted inverted U-shaped model showing the correlation between prior knowledge and interest (Kintsch 1980)

Prior knowledge is also a concern in terms of students cognitive understanding of video and multimedia. As reported by Yang *et al.* (2013), prior knowledge of a domain is a key factor in determining attention allocation while viewing video. Higher attention levels allow learners to decide what information is important and how to organise it into their cognitive schema. Low prior knowledge learners have a harder time than high prior knowledge learners with meaningful learning tasks with the associated imposition of heavy working memory loads. Higher prior knowledge learners have automated certain processes and chunk together pieces of information, reducing cognitive load (Magner *et al.* 2014). Hence, they are not impeded by the fast nature of video.

This was observed in the pilot phase of this research in which the less scaffolded pedagogy did not develop the relevant knowledge among learners which lead to confusion. Whereas it is the position of the researcher that in the next phase, the instructional strategies employed by the teachers allowed the learners to generate a moderate to high prior knowledge with automated process in their working memory. Consequently, the videos were easier to comprehend.

The teacher participants in this phase of research employed a blend of approaches. However, across the board, all teachers, either knowingly or not built up the students' level of prior knowledge and then utilised the video hook. In terms of design, the hooks take a scientific phenomenon and display it in a new way or use it for a new application. However, without a familiarity of the basic phenomenon, students do not recognise the novelty within the video. This finding corroborates the need for technological integration into classrooms and for pedagogy and technological design to work with each other in recognition of the individual merits of each entity.

The next section will examine modifications to the intervention for design cycle 3. Changes will reflect the overall findings, however, more evidence and literature will be presented to justify the motivation behind the amendments being made to methods and design sensitivities in the following phase.

7.4 Changes and Modifications toward Design Cycle 3

The intervention process conducted in design cycle 2 unearthed a number of key facets to hook implementation and corroborated numerous emergent findings from design cycle 1. Starting from a practical orientation, with teachers enacting the hooks how they deemed appropriate, the hooks became part of the learning ecology. As previously noted, prior knowledge was the fulcrum around

which the formerly described student impact turned. As a result, moving forward, prior knowledge will be a key to future instruction. From a design perspective, the hook videos in which cross curricular links played a prominent role will be removed from the suite of eleven as deviant hook examples. This result was flagged in the first design phase and has emerged again as an ‘unwanted’ design sensitivity. From a methodological point of view, the following phase, design cycle 3, aims to build on this research evidence and act as a ‘capstone’ to findings (Long and Hall 2015). In accordance, methodological design modifications are required. These changes, along with all other modifications will be fully delineated in the following writing.

7.4.1 Physics Video Hook Design Modifications

After the analysis of the observations and the interviews, the data signals that the physics hook design was a success in light of how teachers used it as a multi-tool for teaching and learning. Yet, the student reaction was typical of hooks. The design worked in conjunction with the teacher developed pedagogies. The teacher participants in the study were extremely pragmatic in their needs and wants and the hooks fulfilled those needs. The cognitive design, referred to by participants as the open-ended design, proved to be successful in allowing the participants to work with the video and ‘bend’ the uneditable technology to their instructional requirements. With this came a milieu of viable teaching strategies that allow the seamless integration of the videos into the variety of classes visited in design cycle 2. Pertaining to embedded design features, which included relevance, novelty, discrepancy, questioning and cross curricular links, teachers were positive about the first four features. The relevance strategy as noted by the teachers allowed the students to connect with and understand the content of the video on a more personal level. This also played into the novelty aspect of the video. Teachers were positive about a video specifically designed for the Irish syllabus and student body. The questioning strategy, enabled the maintenance of situational interest, while also directing the students’ attention through the video/topic. The final positive design feature and most important was the discrepancy strategy. The discrepant events in the video provided the grounding for the students’ reaction to the videos. With the appropriate knowledge and understanding, students could recognise the anomalies in the videos and they reacted accordingly. This single feature, although related to the other embedded design strategies, proved to be the hinge around which the student impact turned. Based on the summary of the evidence above, it was decided that these elements of the video design should remain the unchanged for design cycle 3.

Chapter 7: Design Cycle 2

One aspect of the video design that was found to be lacking were the cross curricular links. As discussed in chapter 3, the cross curricular links represented part of the overarching relevance strategy. Although the videos are based around the same design format, four of the teachers were critical of two of the hooks, namely the convention and magnetism hooks. This may not seem to be many teachers within the cohort, however, teachers worked with a suite of eleven videos and other participants in this phase may not have encountered or all the videos. Therefore, four of the teachers recognising and discussing the cross curricular links is a significant finding.

At the design phase, these were some of the simpler hooks and to keep them in line with the other videos, it was decided to expand upon their design by linking them to other topics. Hence, they became dual concept videos. The idea behind the design was that demonstrating to students how scientific phenomena can be linked to other topics would broaden the number of students the hook may target. However, the teachers deemed the cross curricular links as non-pragmatic and fuel for confusion amongst the students. Teachers want a specific tool for a specific purpose and the cross curricular links proved too high of a level as one of the teachers explained.

Eva: *“...the magnetism one definitely because it came up with a couple of issues for me, it came up with a couple of issues for me with the teaching of speed and distance and I thought pretty cool, it will be a bit of a precursor to that [...] it’s probably too fast for them.”*
(higher order) (Interview IE215)

The teacher participant added to this later in the interview;

Eva: *“...I think that it confused them in the video about the speed and distance stuff, so I was just like ok that’s one thing the formula, I think as well, it’s probably optimistic to have that much covered in one topic whereas if you did one that was doing speed and distance and you said following on from our magnetism and you actually did like a full length one.”* (Interview 1E215)

The magnetism hook proved to be a point of contention with the teachers. The exact problem from a design perspective is highlighted in figure 7.10. The video moves too quickly from the concept of magnetism to the concept of speed. Initially, the force of magnetism is used to ‘fire’ a ball bearing across a table. It is then attempted in the hook to measure the speed of the ball using the formula $\text{Speed} = \text{Distance}/\text{Time}$. Students had not yet conceptually grasped the magnetism part before moving onto the speed section and the end result was confusion. All teachers in design

cycle 2 flagged both the magnetism and convection hooks as being too cognitively challenging for students based on their cross curricular links strategy.

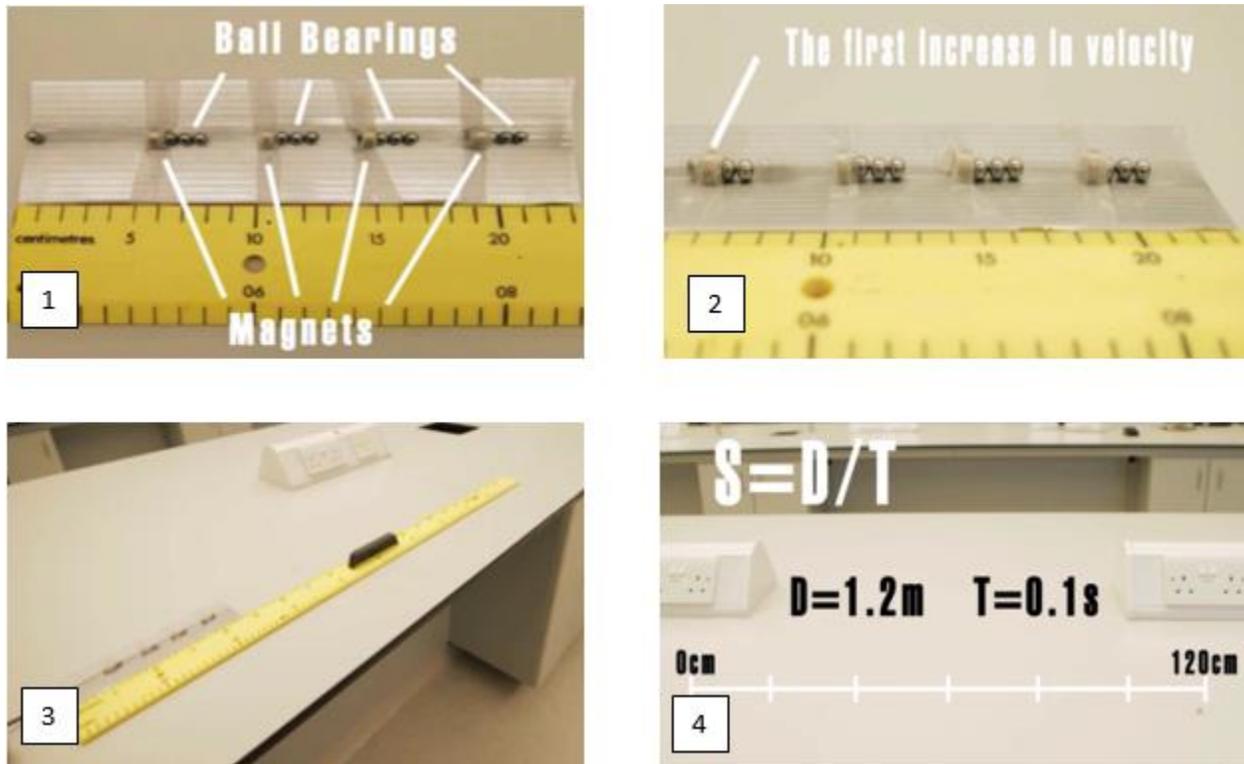


Figure 7.10: Displaying four separate screenshots from the magnetism hook. 1. Displays the set up for the experiment with four magnets and ball bearings (0:20s). The experiment is designed to shoot the end ball bearing down the table. 2. Displays how the velocity of the balls increases due to the force of the magnets (0:39s). 3. Displays how the set up was used to shoot the ball over the surface of a laboratory table (0:59s). 4. Displays the cross curricular link in which the speed of the ball is measured (1:16s)

The cross curricular links, alluded to in the pilot phase and design cycle 2 has been confirmed as a design flaw that is obtrusive to the hooks overall cognitive design. The cross curricular strategy proved to be too abstract for the students to fully grasp the concepts with Yvette making the comment “I don’t think they got that one” (Interview IY15) about the convention hook. The videos proved to be confusing and too much of a deviation from the overarching cognitive design. The purpose of the cross curricular links was to demonstrate how science can permeate throughout other topics and hence, draw more students with a wider array of interests into the science lesson.

However, based on the evidence, this design feature did not complete its function and will be removed for the third iteration. The action taken will remove the magnetism and convention video from the suite of eleven previously available to teachers. The remaining nine videos, only with beneficial design features noted above will be brought forward to the final capstone phase.

7.4.2 Pedagogical Design Modifications

Taking the pedagogy forward into the third design iteration, the beneficial instruction strategies demarcated in this chapter will be further instigated. Teachers again, will be encouraged to have freedom in terms of their own pedagogy, however, instructional guidance will also be offered, in light of the pedagogical findings from this phase. This will include a synopsis of the pertinent teaching strategies for their consideration. However, teachers will be asked that any pedagogies utilised in the third phase must have a focus on the development of prior knowledge.

In keeping with the prior knowledge design caveat, teachers should aim to develop prior scientific content knowledge among students prior to utilising the hooks. This was the keystone to the success of the current phase as evidenced by the hook impact model and the instructional strategies employed by participants. It allowed students to comprehend the video and enabled them to form a clear understanding of the technology and their learning. Thus, allowing students to recognise the science and the discrepancy strategy within the hook. After the pilot, the pedagogical aspect of this study needed to be reconsidered. Building on this, the aim of design cycle 2 was to develop a pedagogical grounding based on practice, rather than editing one from theory. Now that an instructional framework for hooks has been created, it will be assessed and amended in design cycle 3.

7.4.3 Methodological Design Modifications

The information derived from the current phase will inform the methodology utilised in the next phase. As is typical of DBR, the same intervention based approach will be implemented in the final phase. This involves a teacher implementing a video hook with a first or second year class. However, the data collection methods will change as the focus moves from teachers to students. When examining all three phases, the first two phases and their associated data collection methods focused more so on teachers than students as educational resources must first pass teacher level barriers for successful integration in class (Bingimlas 2009). However, the upcoming phase will focus more on the students. The rationale behind working with teachers first in the earlier phases

is that they are responsible for the development of interest (Rotgans and Schmidt 2011b) and engagement (Darby 2005) in their respective classes. Now that the hooks have been tested by the teachers and with feedback in terms of their implementation, design and student impact, it is time to move onto the students and acquire a holistic perspective (Bakker and van Eerde 2015) from the classroom and all end users. As Shephard (2003) denotes, classroom situations are inexact and the impact of a resource depends on both teachers and learners. This decision was also made in conjunction with the Graduate Research Committee (GRC) who recognised the emphasis on the teacher voice up to this point and at this juncture, a more focused student voice is required to garner an all-inclusive view.

Brown (1992) notes that within design research, any data collection methods that answer questions and advance the effectiveness of an intervention can be utilised. The same intervention strategy will be used in that teachers will be asked to use three hooks with either a first or second year class. Teachers will be given all of the supporting documentation and briefed on the design and pedagogical changes from design cycle 2. The student methodological assessments will include group interviews and exit cards. Both will be described presently.

During the last five minutes of each intervention class, teachers will be asked to hand out an exit card to the students in class (see section 5.7). The exit card can be found in appendix C. It asks the students to state what they found to be the most interesting aspect of the lesson and explain why. This strategy has been informed by Mitchell (1993) who used naturalistic qualitative techniques to garner an understanding of student perceptions of interest within their own classrooms. Within Mitchell's study, methodologies included focus groups and open-ended questionnaires. In the questionnaires, students were asked to list the aspects of their class they found interesting or boring and then state why. Such a qualitative approach will be adopted in this research and should provide confirming evidence as to the impact of the hook video from the students' perspective, while also garnering short descriptive accounts from the students about their interests in relation to science lessons. Furthermore, after completion of the three hook interventions, the researcher will conduct group interviews with students (see section 5.8). There will be four students in each interview and they will be asked about their perceptions of the video hooks, what kind of impact it had on them, how they work with the videos and finally on the video

design. As such, the group interview follows a similar line of questioning to the teachers based interviews.

Pertaining to the teacher participants in the final iteration, they again will be asked to conduct the hook interventions, but will be asked to maintain a teacher record of their activities. This is so the researcher has a log of what hooks were used in class and how they were employed. The journals can then be triangulated against the data generated from the student exit cards and group interviews. After every intervention, teachers will be asked to record and describe in their journal the hook that was used, the teaching strategy that was utilised in association with the hook and the student reaction. Teachers were excellent at effectively answering such questions in the interview and the journal will provide similar feedback for the upcoming phase. In summation, the focus moving forward is on the student perspective, yet the data generated will extend to teachers to provide confirming evidence in line with student responses.

7.4.4 The Emergence of Para-Hooks

As noted in this chapter, the hook was described as a multi-tool by participants. Teachers utilised the hook in a variety of ways during observations but, none used the video during the lesson introduction as per the definition of a hook in this thesis. Yet, the pedagogy enacted by the teachers enabled the hook based reaction of attention, interest and engagement grounded in the design of the videos. At this point, the video hooks do not adhere to the majority based definition of a hook, but align more so with McCrory's (2011) definition in which the author posits that hooks can and should be placed at various times during the lesson in support of creating an interest driven learning environment. The initial design sets out that the videos should operate in isolation at the start of the lesson and act as a hook. Yet, the evidence presents a scenario by which the current design cannot be used in isolation and is only actualised through its effective incorporation into the wider pedagogy. With the current findings, it can be articulated that a new type of hooking methodology has been uncovered, one that adheres to augmenting students' attention, interest and engagement, but does not have to be placed at the beginning of instruction. As such, the new hooking typology is an extension of the literature and emergent in this design cycle is the para-hook. A para-hook is a short instructional strategy utilised to augment students' situational interest and engagement at various time intervals other than the lesson introduction. As such, it is an extension of traditional hook strategies. This is one of the largest findings of this design cycle and will be examined further in next set of interventions.

7.5 Findings Summary

Evidence from the findings section detail the student impact of the hooks in terms of situational interest with observable links to engagement and attention. The overall reaction can be described through a knowledge gap theory that came about due to the effective combination of pedagogy and the hook design. The key instigator of change during this research phase was the teachers' awareness of the need to develop prior knowledge among the students before viewing the hook. This enabled the integration of the video hook with the development of the associated hook impact model. Within this phase, the videos were applied as para-hooks and proved to be an effective teaching and learning tool when integrated into an activity and when pedagogy is designed to complement the video. Indeed, it should also be noted that the design of the physics video hooks allowed for the development of and implementation of a variety of pedagogies. The video hooks acted as a catalyst for the development of situational interest among students in this phase. Some teachers started referring to the hooks as “launch pads” or “multi-tools” as they were the key driving factor within many of the pedagogical frameworks developed. The links between the video design and pedagogy are now established under the umbrella term, para-hook. The pedagogy, with its particular focus on prior or experiential knowledge, allowed the design to flourish and be enacted in the classroom as it was originally conceived. Comprehension was the key driving factor in this design cycle.

These findings will be further advanced in design cycle 3 or the capstone phase. The final phase will conduct more interventions, however, it will adopt and implement the findings of design cycle 2. The aim will be to continue to receive feedback on the application of the physics video hooks. The exact changes are detailed in the following chapter. Summarising this phase and the findings, in terms of the hook intervention, the proto-theoretical framework developed is diagrammatically represented in figure 7.11 below. It will be the framework examined and progressed into the forthcoming design cycle.

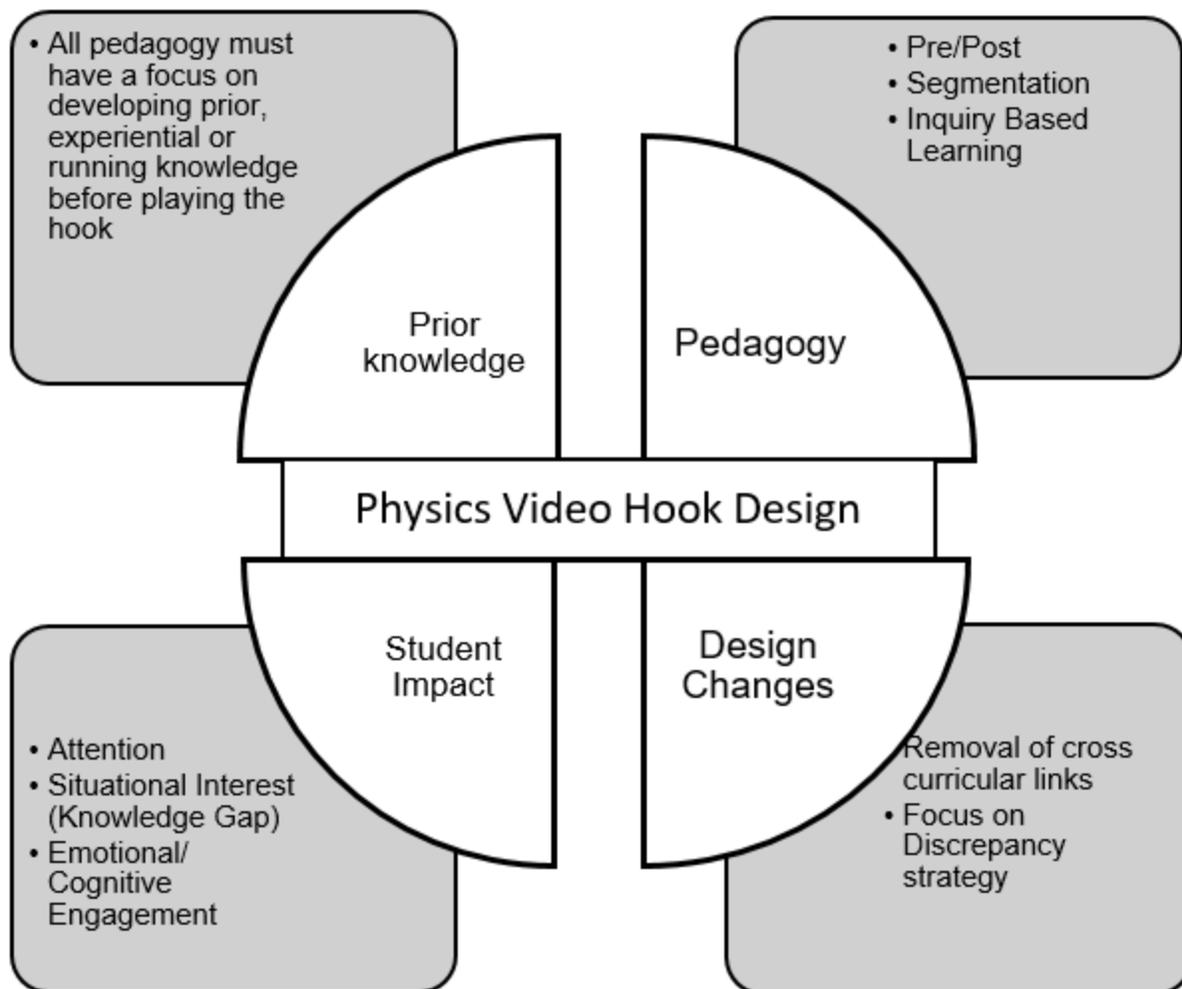


Figure 7.11: Diagrammatical representation of proto-theoretical framework developed from design cycle 2

7.6 Chapter Summary

This chapter has discussed design cycle 2 when the video hook intervention progressed from the pilot phase to the mainstream within the junior science classroom. The chapter firstly outlines the influence and grounding of the design cycle 2 from the pilot phase and then explains how the hook intervention was expanded into in-service teachers' classrooms. The findings were framed and discussed in terms of student impact, pedagogy and video design. Evidence was presented in both confirming and disconfirming manners to illustrate various phenomena throughout the intervention. The next chapter, design cycle 3, represents the third design cycle and the last of this research project. It will simultaneously test and advance the theory and practice developed in chapter 7.

Chapter 8: Design Cycle 3

8.1 Chapter Introduction

This chapter will discuss design cycle 3, the ‘capstone’ phase of this research. As such, it aims to support and verify findings of previous design iterations, while also enabling the opportunity to uncover new results. The chapter presents a narrative pertaining to the physics video hook implementation. Firstly, the intervention process is discussed (8.2), followed by the emergent themes (8.3). Evidence will be presented with exemplars of data, framed initially in terms of pedagogical approaches with concurrent analysis of the student voice.

8.2 Design Cycle 3: Implementation Strategy

8.2.1 Overview

DBR creates grounded design principles through intervention and reflection. Design principles should reflect the environment in which they were developed (Anderson and Shattuck 2012). Given this, the final intervention phase takes the results of the former and advances both theoretical and practical design principles within the classroom context once again. Design cycle 2 unearthed key findings in relation to pedagogical implementation and student impact, both of which will be explored in the following sections. Design cycle 3 works with a sub-sample of the same cohort of teachers, enabling an evolved, in depth examination of the hook implementation and impact.

This intervention and associated research methods have been developed to answer the primary and subsidiary research questions;

How can physics video hooks be designed and implemented to generate student attention, interest and engagement in physics?

a) Does teaching with video hooks have the potential to target junior science students’ attention, interest and engagement in physics lessons?

(b) If so: what are the integral components of physics video hooks from both technological and pedagogical design perspectives that shape the development of student attention, interest and engagement?

Design cycle 3 will be demarcated thusly.

8.2.2 Pedagogical Design

Emergent from design cycle 2, embedding the videos within the context of the lesson, not as an isolated event at the beginning of instruction, but rather as an integral component of the lesson, enabled the emergence of para-hooks and a student reaction grounded in situational interest. As noted, various methods were employed in association with the hooks, the motivation of which was based on teacher's pragmatic application of the technology. Although the pedagogy was diverse, it became apparent that the generation of prior, experiential or running knowledge was common across para-hook strategies and fundamental to enabling a positive student reaction. In design cycle 2, the hook required a 'preparation phase' to prime students. In acknowledgement of this, teachers in the third phase will be asked to utilise similar strategies to the ones employed before; pre/post, segmentation, inquiry based learning and post revision strategies, with a specific focus on the generation of prior knowledge. The goal is to reinforce the findings of the second intervention while also enabling the discovery of new findings (Long and Hall 2015).

8.2.3 Physics Video Hook Design

Grounded in data from the previous phases, the largest 'design flaw' flagged by all teacher participants was the cross curricular link strategy, that was strongly present in both the magnetism and convection hooks. As deviant examples within the suite of eleven, both of these hooks will be removed for design cycle 3. The remaining nine physics video hooks will be available to participants in the current intervention.

8.2.4 Intervention Design Modifications

The changes to the intervention design were based upon the findings in design cycle 2. The amendments endeavour to advance hook theory in the science classroom. The proto-theory developed is represented in Figure 8.1.

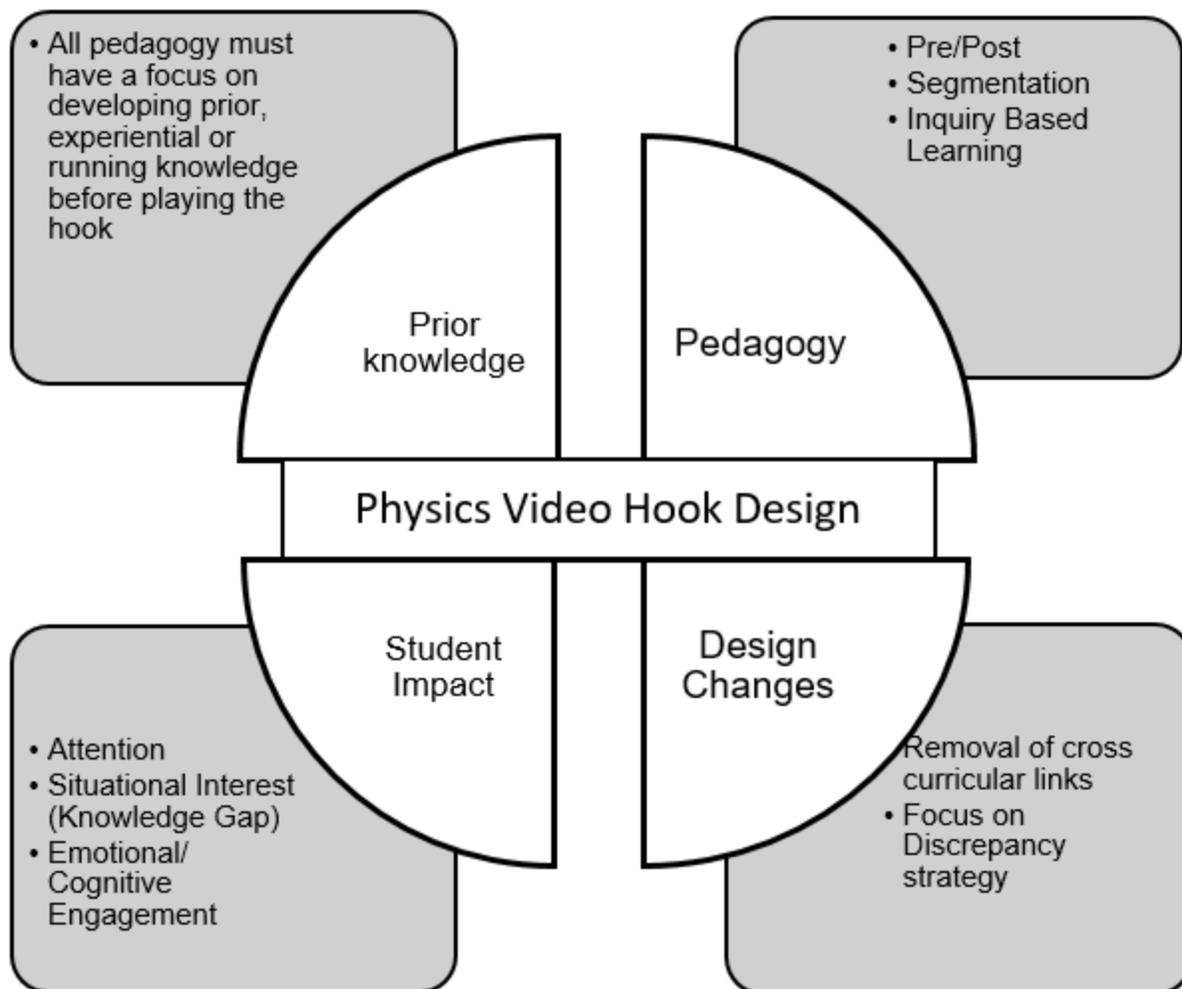


Figure 8.1: Diagrammatical representation of proto-theory derived from the data in design cycle 2 being implemented in design cycle 3

The above theory was developed in design cycle 2 and is utilised throughout design cycle 3. As evident in the diagram, the main modifications include a focus on prior knowledge throughout pedagogy, the removal of cross curricular links design element, the development of situational interest and a focus on the discrepancy strategy embedded within the videos in lieu of creating knowledge gaps among students.

8.2.5 Conjecture Map

The conjecture map for design cycle 3 (figure 8.2 below) represents the current intervention and predicted path based on the design artefact and theoretical derivations in this study with the speculated outcomes.

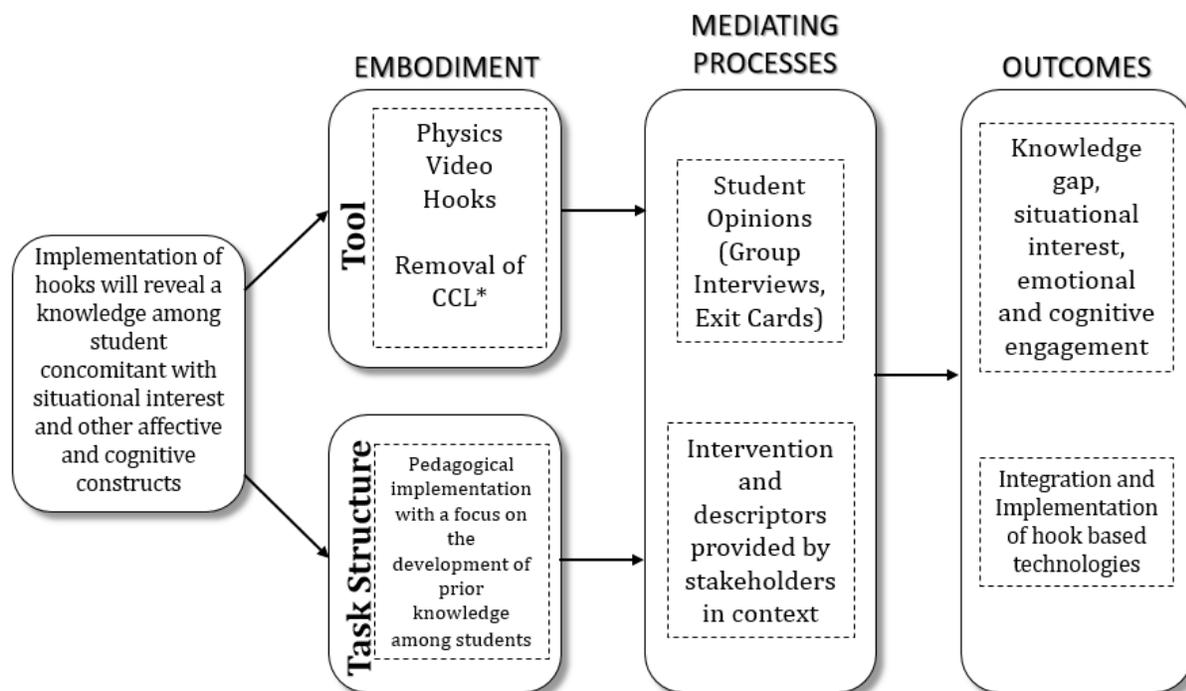


Figure 8.2: Conjecture map summarising the enactment of; and predictions in design cycle 3. *CCL refers to Cross Curricular Links (Sandoval 2014)

8.2.6 Methodology

Design cycle 3 takes the form of a qualitative intervention. An examination of students' perceptions is warranted to attain a holistic view of all stakeholders within the context of the secondary science classroom. Given this, the intervention methods take a different form as Brown (1992) notes that any method is appropriate in design studies to aid in answering the research questions. Furthermore, the methodological design of the current phase takes into account the larger number of student participants when compared to teachers. The following research tools aim to valorise the student voice in its entirety.

In a similar vein to design cycle 2, the current cycle is enacting three interventions per teacher participant. Based on the results of the former phase, three interventions are approximately the amount a teacher can conduct in the four-month testing period when taking into consideration the tripartite separation of junior science and the number of topics the remaining nine hook videos cover. Four teachers of the previous cohort were recruited as the current phase is enacting an in-depth examination of the hooks, mainly from the student perspective. These teachers were selected using a theoretical sampling frame as they were the teachers who engaged the most with the hook technology. Hence, four classrooms, with three interventions and approximately twenty students

per class offers considerable depth and generalisability. Working with the same participants bolsters the credibility of the study as their longitudinal implementation of the hooks is being examined. Another advantage is their potentially evolving viewpoints based upon their incremental experience with the hooks, something that new participants would be lacking. Teachers will be asked to use the hooks in line with the pedagogical design modifications described previously (Figure 8.1 above). Furthermore, teachers will be asked to keep a structured reflective journal of each class in which they employ a hook.

In assessing students' ideas pertaining to the hooks, a confirming strategy used to validate the results of the previous phase, as derived from Mitchell (1993) and action research approaches (Klein *et al.* 2015, Owen and Sarles 2012) will be utilised. As noted by Palmer (2009), when assessing situational interest, it is advised to use a brief procedure for gathering data so not to hamper the naturalistic context of the classroom. In accordance, an exit card strategy will be used at the end of every class in which a hook is used that asks students to write down the most interesting part of their lesson and explain why. This will give an indication of the hooks' placing within the classroom ecology pertaining to its intended outcome of interest development associated with the formation of a knowledge gap per the results of design cycle 2.

In addition, to provide in depth exploratory data (Frey and Fontana 1991) and as a method of corroboration through triangulation (Creswell and Miller 2000, Gibbert *et al.* 2008), group interviews will be used to garner an insight into student opinions pertaining to the hooks impact, design and implementation. In a British study, Palmer (2009) used group interviews after science lessons that focused in inquiry to assess sources of interest. Students were asked to reflect back on their experiences and indicate their personal levels of interest and in doing so, describe their interest. To maintain the naturalistic context of the classroom ecology, the group interviews will take place in each of the three schools, after all three interventions have been completed. In relation to validity and credibility, the researcher is aware of the powerful differentials that may be present when interviewing children (James 2007), which may entice them to respond in particular ways (Creswell 2013), something that is exacerbated when the interviewer is a teacher as in the current research (Cohen *et al.* 2011). In light of this, the researcher will aim to develop a rapport with participants by talking to them about the purposes of the interview, allowing them to create their own synonyms and by playing one of the hooks as an icebreaker. This is to establish a safe

environment in which participants can share their experiences (DiCicco-Bloom and Crabtree 2006).

One of the distinct differences between design cycle 3 and the previous cycle is the involvement of the researcher pertaining to data collection methods. In design cycle 3, the researcher is removed from the classroom, hence enabling the interventions to play out in a natural manner. Barab and Squire (2004, p. 10) argue that “if a researcher is intimately involved in the conceptualisation, design, development, implementation, and re-searching of a pedagogical approach, then ensuring that researchers can make credible and trustworthy assertions is a challenge”. In concert, Anderson and Shattuck (2012) argue that the researcher’s intimate involvement with a study can be as much of strength as a weakness. A researcher needs to support an intervention, however, there is a fine line between objectivity and bias. To demonstrate objectivity, the methods selected will test the results and findings of the previous phase with a minimalist and remote participation from the researcher. Therefore, the current methods being employed in design cycle 3 aim to advance the validity of this thesis.

8.2.7 Data Analysis

Data analysis for design cycle 3 followed the protocol set out in the methodology chapter. However, in this phase, items for analysis include exit cards, teacher journals and student group interviews. All of the data collected was coded using manual methods for first cycle coding and NVivo data analysis software for second cycle coding (appendix D demonstrates the development of sub-codes to categories and themes) (Saldaña 2012). The hybrid thematic analysis (Clarke and Braun 2013, Saldaña 2012) was utilised to develop a thematic map for the design cycle 3 (figure 8.3). Within the map, the focal points are pedagogy and student impact with associated offshoots identified in line with the research objectives and emergent data. Arrows and associations displaying the types of pedagogy utilised in accordance with teachers’ pragmatic application of the hooks. Additionally, various elements of the student reaction to the hook are represented in light of the impact of discrepant phenomena in the video hooks. The thematic map is derived from evidence within coded data. It informs the interplay between thematic and theoretical considerations throughout the third phase of research. The themes derived from thematic analysis and the entire coding process are discussed within the following findings section and elaborated upon and explained with pertinent literature.

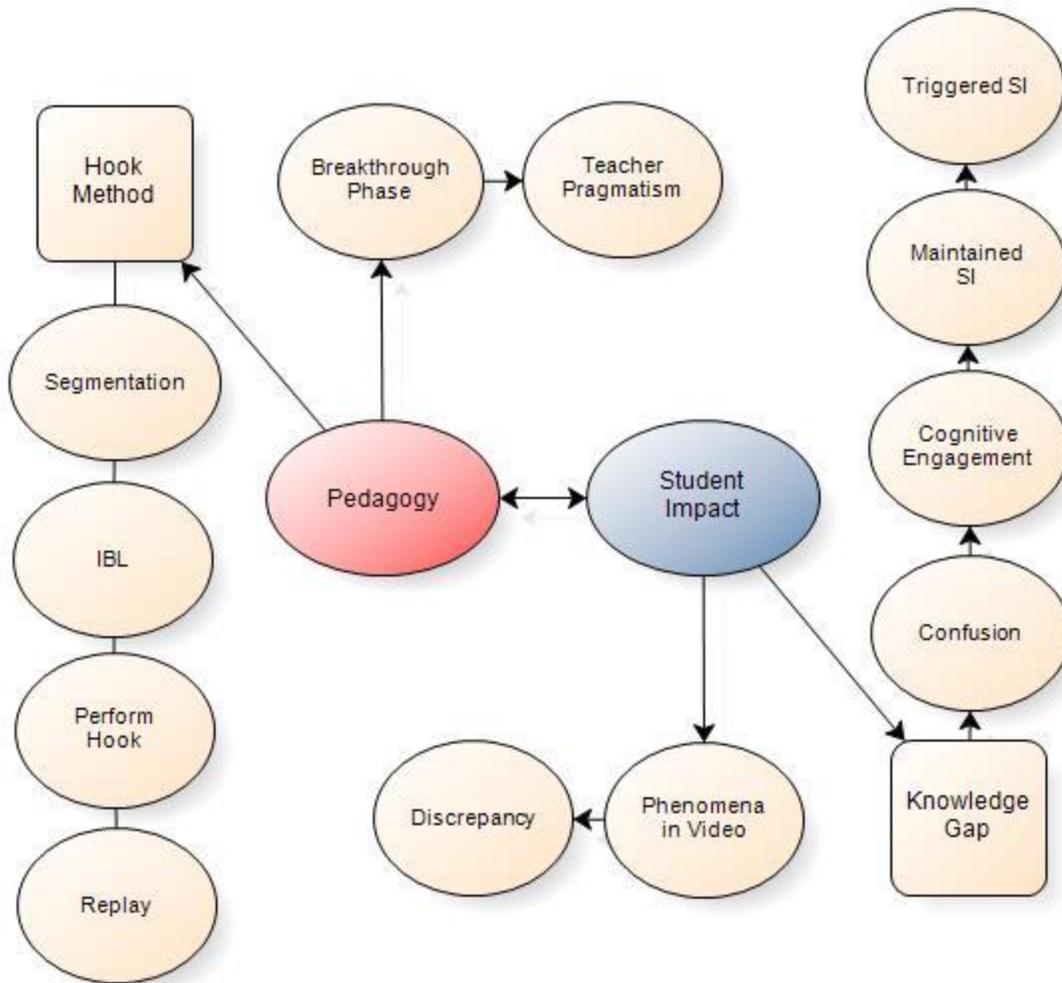


Figure 8.3: Thematic map derived from data in design cycle 3

8.3 Design Cycle Three: Findings

Findings from the group interviews, exit cards, teacher journals derived from the multi-site teacher interventions are presented thusly. Findings are represented as emergent themes abstracted during data analysis. In keeping with previous chapters, the pedagogy employed by teachers will be initially explored in light of their evolving classroom goals. Secondly, the student impact will be discussed to further examine existing themes while also enabling the discovery and discussion of new ones.

8.3.1 Evolving Pragmatism: Reaching Plateaus and Crossroads within Instruction

Throughout the third intervention, teachers were once again asked to implement the physics video hooks. Specific instructions were given, in that teachers were asked to use the videos as para-hooks

per the previous cycle. Teachers were also informed about the key role that prior knowledge played in students' understanding of the videos and asked to maintain this feature so that similar student experiences would be facilitated. However, upon examination of the teacher journals, it was determined that the teacher's instructional approaches in some cases evolved, while others plateaued. Table 8.1 demonstrates the complete list of strategies employed across all three interventions within design cycle 3. Surprisingly, if we consider the eleven interventions employed within the four teachers' classrooms, many of the teachers moved from the para-hook methodology, to employing the hook during the lesson introduction. This was evident in ten of the eleven classroom interventions.

Table 8.1: List of interventions conducted by participants and associated teaching strategy

Teacher	Teaching Strategy
Bill	
Lesson 1	Watch hook for homework, Hook at the beginning of instruction, Replicate the hook, Confirmatory IBL
Lesson 2	Watch hook for homework, Hook at the beginning of instruction, Replicate the hook, Confirmatory IBL
Lesson 3	Watch hook for homework, Hook at the beginning of instruction, Replicate the hook, Confirmatory IBL
Denise	
Lesson 1	Hook at the beginning of instruction, Co-operative learning, Confirmatory IBL
Lesson 2	Hook at the beginning of instruction, Co-operative learning, Confirmatory IBL
Lesson 3	Hook at the beginning of instruction, Co-operative learning, Replays, Confirmatory IBL
James	
Lesson 1	Hook at the beginning of instruction, Replicate the hook, Confirmatory IBL
Lesson 2	Hook at the beginning of instruction, Replicate the hook, Confirmatory IBL
Lesson 3	Hook at the beginning of instruction, Replicate the hook, Confirmatory IBL
Eva	
Lesson 1	Hook used in the middle of instruction, Segmentation
Lesson 2	Hook used at the beginning of instruction, Replicate the hook, Confirmatory IBL

One of the teacher participants, Bill, arrived at a point in his instruction in which he utilised the same instructional strategy throughout all three interventions. Students were asked to watch the hook for homework in advance of the next class in which they would attempt to perform the hook. The hook was shown again and students began working on trying to replicate the video. In this instance, the teacher has found his instructional niche. One that he repeats and notes that;

Bill: *Over the course of the three hooks, student engagement with the website (hooks on YouTube) has increased massively... (Teacher Journal TJB16)*

Chapter 8: Design Cycle 3

It seems that throughout the three interventions, his strategy has become more successful as students became more accustomed to the instructional approach. In the previous phase, Bill did ask students to watch the hook for homework and then used IBL, however, the hook was used in the middle of instruction. As can be observed, now the hook is placed at the beginning. Indeed, Bill's strategy has evolved from the previous cycle and he has arrived at a pedagogy which is situated in his context.

Denise followed a similar pattern, in the previous phase, she used the hook in the middle of instruction, yet in this phase has placed the hook at the beginning of her teaching and adopted a think pair share strategy along with driving questions, coaxing and prompting. Essentially, the teacher is attempting to replicate the IBL thinking processes without the practical element so that students have to cognitively negotiate the hook. In her reflective journal, she notes that she used the hook at the start of the lesson to;

Denise: *...use the hook as a 'hook'.* (Teacher Journal TJD16)

In her second lesson, she justified the same approach by noting;

Denise: *I thought it worked well in last lesson in engaging students with the topic so tried to replicate that.* (Teacher Journal TJD16)

This suggests that Denise has continued to experiment with her utilisation of the hooks and having found a format that she likes, has stuck to it. Indeed, in her third lesson, she reports that;

Denise: *Students seem to like discussing what they have seen and learned from the hook.* (Teacher Journal TJD16)

As can be derived from the data, the teacher evolved in terms of her integration of the hook and is pragmatically deciding 'on the fly', grounded in contextual feedback, how the technology should be integrated into her teaching.

Next is James who used the exact same strategy as the previous cycle, excluding the fact that now he has placed the hook at the start of the lesson as opposed to the middle. He notes in his first lesson how he used the video as a "pure hook" (Teacher Journal TJJ16). It seems that the teacher has determined that hooks traditionally belong at the start of the lesson, however, can be placed at other time intervals throughout instruction. In his third lesson reflection, he notes that he uses the hooks to;

James: ... *clarify or test prior knowledge.* (Teacher Journal TJJ16)

With this, the argument can be made that the hook is potentially being used as a sort of assessment at the start of class, an event used to determine the direction of his following instruction.

The last teacher Eva conducted two interventions and was the only teacher to use the hook as she had in the previous phase, in the middle of the lesson, however, in her second lesson, she used the hook as the introduction. This could be evidence of continued exploration with the videos and also indicates along with the data from other teachers that, teaching strategies employed in association with the hooks are seemingly improvised and innovated based on in-class assessments. In some cases, if they deem a strategy to be successful, they will continue to implement that technique, however, the data does not suggest that teachers would then be limited to such pedagogical methods. They appear to adapt their choice to the particular teaching scenario.

However, through the analysis of each teacher's pedagogy, the researcher is left with one overarching question. Why did teacher participants place the hook at the start of the lesson as opposed to the middle in the previous cycle? Pedagogically, design cycle 2 and 3 are similar pertaining to techniques utilised in association with the hook, however, in design cycle 2, teachers prepared students for the hook. In the current cycle, teachers employ pedagogical exploration of the hook content. One potential justification, derived from the teacher journals is that upon hearing that prior knowledge was a key determinant of student understanding that teachers modified their teaching so that they could assess levels understanding about a particular topic by placing the hook at the start of the lesson. This would make sense as the confirming IBL strategies, whereby students receive the question, method and results, were used to explore the students' ideas and misconceptions before the hook was either explained to them by the end of instruction, or the students themselves had figured it out through the various inquiry based methods. James lends credence to this hypothesis by noting that he uses the hook to clarify and test prior knowledge. As such, the teacher is establishing his hook application on immediate contextual feedback, opinions and observations (Gerard *et al.* 2011).

Another hypothesis is that teachers felt that students had adequate levels of prior knowledge since the hooks were used mid topic in ten of the eleven interventions. As a result, students had a certain level of prior content knowledge, which teachers may have felt was enough to allow for their interaction with the video hook.

At this point, either hypothesis could be true as the integration of the video hook into the naturalistic classroom context became increasingly complex in design cycle 3. Numerous authors discuss the process that teachers go through when implementing and integrating technology. Pegrum *et al.* (2013) notes how teachers have to learn how to integrate technology (Ertmer and Ottenbreit-Leftwich 2010), while Inan and Lowther (2010, p. 138) describe this as a “slow and complex process”. As referenced previously, Hooper and Reiber (1995) purport that with any new technology a teacher goes through a number of phases including familiarisation, utilisation and integration. The current research fits with this model, but expands on it as teachers have demonstrated that the utilisation process can take many forms and evolve until teachers eventually end up at a preferential strategy for a particular context; as in the cases of Bill, Denise and James, somewhat of a ‘troubleshooting’ process (Gerard *et al.* 2011). Multiple authors also note that the factors that influence a teacher’s use of ICT include personal pedagogical practices (Kim 2013, Law 2009, Weld 2004). In studies relatable to this one, teachers’ practices changed across interventions due to variations in knowledge, confidence (Campbell *et al.* 2015) and exposure over time (Bitner and Bitner 2002, Ertmer and Ottenbreit-Leftwich 2010, Hew and Brush 2007, Mishra *et al.* 2009, Wachira and Keengwe 2011) and this may have been the case in the current research.

In essence, the teachers changed their pedagogy from one based in the middle of the lesson to one based at lesson introduction, which is more in line with the traditional definition of hooks. The specific times the current teacher participants utilised the hooks during observed lessons in design cycle 2 are displayed in table 8.2 below. They are in stark contrast to the current design cycle, in which teachers placed the hook as the lesson introduction in ten of eleven interventions.

In the pilot, when the hook was employed at the beginning of instruction and the student impact was that of confusion. The videos were utilised as an isolated event within instruction and represented a pedagogical tool that students could not cognitively negotiate. Conversely, in design cycle 3 the pedagogy was vastly different due to teachers continually referring back to the hook and using it as a driver for inquiry, yet the hook was employed as the lesson introduction. Such a prominent comparison warrants an examination of the video hooks impacts on the students in the current intervention. At first, the discussion will explore the 185 student exit cards followed by the qualitative articulation of emergent results from the six student group interviews and teacher journals.

Table 8.2: Time at which the hook was initiated during observed lessons in design cycle 2

Teacher	Time hook was played during observed lesson
James	27 minutes
Eva	60 minutes (double class)
Denise	15 minutes
Bill	16 minutes

8.3.2 Reinforcing Knowledge Gaps within the Complexity of the Science Classroom

The research methods employed in design cycle 3 were utilised to provide confirming evidence pertaining to the observed student impact in design cycle 2. The former student reaction, derived from researcher observations and teacher interviews is presented in figure 8.4.

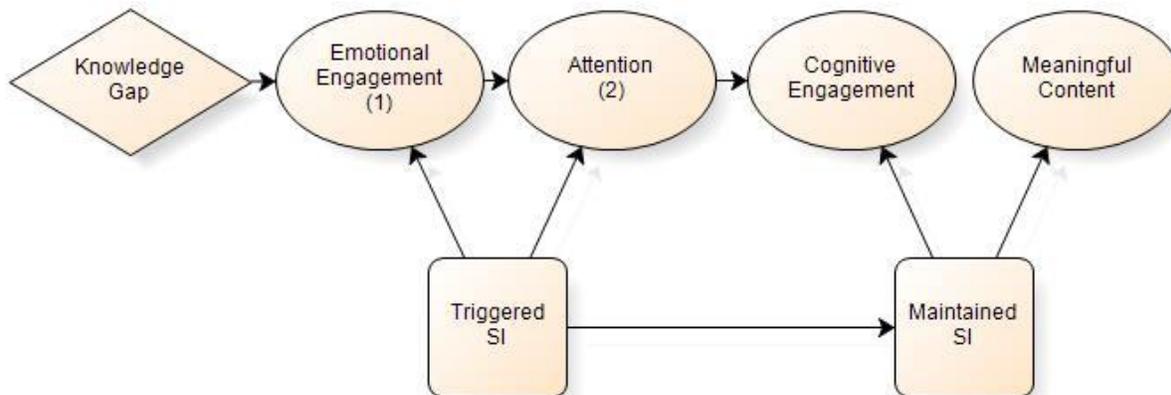


Figure 8.4: Student impact model derived from data in design cycle 2

Hypothesised within the model, is that the para-hooks revealed a knowledge gap in the students’ cognitive schema leading to a triggered situational interest concomitant with an observable emotional engagement and attentive behaviour. Further data from teacher interviews and observations evidenced that the situational interest was maintained and represented through cognitive engagement. Additionally, findings suggested that the hooks were a meaningful event within pedagogy to the majority of the student body. Fundamental to the model is the generation and maintenance of situational interest. As a source of confirming evidence, an exit card strategy was employed in the current phase (Klein *et al.* 2015, Owen and Sarles 2012). Based on a qualitative assessment utilised by Mitchell (1993), the exit cards represent a small qualitative

survey which asked; ‘What was the most interesting thing/part of today’s science class?’, the follow up question asked; ‘Why?’. With this, the research endeavours to lend credence to the claim that the video hook represented a focal point of student interest within the overall complexity of the lesson. The second question of ‘Why?’ will allow the researcher to garner an insight into the processes at play in relation to the generation of interest, hence, allowing for validation of the former student impact model.

Results of the exit card survey are presented in table 2 and figure 8.5 below. A total of 185 exit cards were completed by students across the four classrooms and respective interventions. Pertaining to question 1; ‘What was the most interesting thing/part of today’s science class?’, students responded broadly with one of seven answers. This is illustrated in table 8.3.

Table 8.3: Response categories to question 1 with number of respondents and percentage of whole

Response to Question 1	Number of Respondents	Percentage
Phenomena in Video Hook	57	31%
Practical Work	40	21%
Other Scientific Phenomena	29	16%
Video Hook	25	13%
Phenomena in Video Hook/Practical	16	9%
Classroom Activities (Group work etc.)	16	9%
Random	2	1%

The following writing will discuss the exit card results with reference to the group interviews and teacher journals to contextualise the evidence. Starting with the responses pertaining to practical work and classwork, the discussion will lead to the proportion of students that described the phenomena in the video hook as the most interesting aspect of their lesson.

Evidenced in the data, one-fifth of students described practical work or performing an experiment as the most interesting part of their lesson. As mentioned previously, teachers would often play the hook and get the students to recreate the phenomena observed using an inquiry approach. The result is in alignment with a plethora of studies that present practical work as a key facet of science and physics (Oon and Subramaniam 2011) instruction pertaining to student

situational interest and enjoyment (Abrahams 2009, Abrahams and Reiss 2012, Daschmann *et al.* 2011, Regan and Childs 2003, Walper *et al.* 2014). Swarat *et al.* (2012, p. 515) notes “...when judging the interestingness of an instructional episode, students focused primarily on the form of activity...”. Furthermore, according to Abrahams and Reiss (2012, p. 1036) students see “practical work as being both affective and effective in terms of their enjoyment and learning of science” with enjoyment being a construct that can be theoretically aligned with levels of interest (Ainley and Ainley 2011, Köller *et al.* 2001). This was apparent in Bill’s third class in which the students watched the ‘Pressure’ hook. In this video, a balloon is popped on a single nail, but doesn’t pop on a bed of nails. After watching the video, the students were allowed to perform the hook and twelve of the fifteen exit cards directly stated that the practical work, which involved popping balloons, was the most interesting aspect of the lesson.

Q 1. What was the most interesting thing/part of today’s science class?

Popping the balloons.

Q 2. Why?

It was funny and good craic. (Exit Card ECB316)

In the above example, as in many others, the enjoyment derived from popping balloons and the social aspect of having fun in class dominated the students’ perception of what was interesting in the lesson. Practical and hands-on work, as a form of active learning, is closely associated with interest development (Swarat *et al.* 2012) as it allows students freedom to explore and act autonomously (Walper *et al.* 2014). The fact that students had a level of control, could draw faces on the balloons and investigate the science in their own way may justify why practical work proved to be a key driver of interest.

Further results from the exit cards indicated that 9% of students found their classwork to be the most interesting part of the lesson. In this instance, classwork refers to group work, think pair share and various other social aspects of instruction. Indeed, the social component of class, whether it be in a practical sense as above, or in a non-practical instructional episode, was a strong influence on the students’ interest (Gokhale 1995, Mitsoni 2006, Zahorik 1996). As reported by Rotgans and Schmidt (2011b) working in small groups helps maintain interest as it fosters a sense of belonging. Mitchell (1993) posits that group work acts as a form of social stimulation and how

in general, adolescents are a social group that seek out shared experiences, hence, its inclusion in the exit card results are not surprising.

Another interesting result is that 13% of students directly referenced the video hook in particular as the most interesting aspect of instruction. Although the selection of video as the hook medium was deliberate, it was not expected that students would describe the process of watching the video as the most interesting aspect of instruction. However, the student group interviews shed light on this result. Firstly, the students readily identified themselves as being digitally literate and completely accustomed to videos. In their minds, digital media was ‘their’ domain as is evidenced below;

Mary: *“But if you think about like our generation, we’re kinda, books are good yes, but in our generation we are more like technology, like we have grown up with more like technology, so we’re like more used to watching videos and using social media, so it would be more easier for us through what we are used to as well as the book, like books are still good but.”* (Group Interview GIJ216)

In this incidence, Mary has identified a generational gap. Her generation being one completely in tune with social media and technology. It is also evident that she compares the videos to the mainstay pedagogical platform of books. Her ideas align with Prensky (2012) who makes the distinction between digital natives and immigrants. Mary recognises herself as a native and such views could be the reason why students ‘tune’ into the video hooks and chose them as one of the most interesting aspects of their instruction. Another student, Daniel, makes another argument pertaining to the videos;

Daniel: *“Eh, it makes it kind of, because maybe if I just see the video and then I am like whoa that was really good like, I can’t wait to do it, and I kinda think that physics is such a good thing but without, without the video, I’d just be like oh physics is just not my thing.”* (Group Interview GIB116)

This a very strong statement from Daniel, in which he indicates that the video’s display of the physics concept draws him in, interests him in the topic and without the additional presence of the digital technology in the class, that he feels his opinion of physics would plummet. In accordance, a signature theme of the group interviews was the positivity students had toward video and the video hooks, in particular when they drew a comparison between engaging in video experiments,

and their reality of reading experiments in their textbooks, prior to implementation. This was noted in all six group interviews,

Dana: *“Em, so instead of the teacher talking about it, there’s an actual performance to explain exactly what you are talking about.”*
(Group Interview GID116)

Cathal: *“Because in the book you can’t see what’s actually happening.”*

Matthew: *“It’s just a picture and you can’t relate to it.”* (Group Interview GIB116)

Jack: *“It’s more interesting if you’re watching a video than just like taking down notes or reading out of a book.”* (Group Interview GIB216)

Jerry: *“Well its easier like to look at something than, than your reading about it. It’s much easier to understand when you’re watching it happen then.”* (Group Interview GIJ116)

A consistent theme that emerged was that students would compare reading to video and describe video as being more interesting than ‘just reading’ as Hong *et al.* (2014, p. 110) elucidates “what the eye can see makes it true.” Moreover, the visual aspect of video was fundamental to fast and efficient learning in their minds. Walper *et al.* (2014) notes how writing and reading are a students’ base by which they judge other activities. In this instance, they were favourable toward video. Card (2012) positions video as a dominant form of media that take priority in the learner’s mind. Moreover, Winkler (2005, p. 5) reports, “80 – 90% of all neurons in the human brain are estimated to be involved in visual perception.” Humans are adapted to interact with moving visual images, the same we encounter on a daily basis (Miller and Zhou 2007, Vaughan 2004). The information rich and realistic contexts of the hooks were a welcome addition to the science classroom, particularly when an IBL approach is being utilised and the video is a better guide to (Schwartz and Hartman 2007) completing the task over a written description. The data suggests that a cohort of students simply found the process of watching a video (in this case the video hook) as the most interesting part of instruction. As noted in chapter 3, the choice to create the hooks in a video format was explicit. It was unexpected that the choice would have such an impact on student

interest. Yet, this result aligns with literature describing today's students as the 'google eyed' generation (Duffy 2007) or as digital residents (Connaway *et al.* 2011, White and Le Cornu 2011) completely attune to digital media. In light of the result, it seems that the physics video hooks were a welcome addition to the classroom structure.

The results presented thus far resonate with the literature pertaining to student interest. Yet, the largest determinant of interest was the content of the video hooks situated at the beginning of the lessons. Findings from the student exit cards specified that the phenomena in the video hooks was the most interesting aspect of all interventions (31%). Moreover, it should be noted that 9% of responses described both the phenomena in the hook and the practical work as the most interesting part of instruction. Furthermore, as previously noted, 13% of students stated that the most interesting part of their lesson was the video in and of itself. The culmination of which is potentially 53% of students rating the physics video hooks as the most interesting aspect of instruction. In light of these results, the argument can be made that the hooks represented the single most interesting aspect of instruction across the eleven interventions enacted in design cycle 3. It can also be postulated that the core of the student impact model, the development of situational interest, has been shown to be a consistent occurrence across design cycles and interventions. Indeed, the goal of the capstone phase is to reinforce the results of the previous phase (Long and Hall 2015) and the exit cards have corroborated previous findings, while also enhancing the trustworthiness and credibility of the findings in design cycle 2. However, at this point, the discussion must examine the 'whys?' of the exit cards to glean an insight into the students' reasoning. Why did students deem the video hooks to be the most interesting aspect of their instruction? This will be explored next.

As noted, 31% of students directly referenced the phenomena within the video hooks, as the most interesting part of their respective lessons. The students' justifications fell into one of three response categories displayed in table 8.4.

Table 8.4: Response categories determining students' choice of the hook content as the most interesting part of their lesson

Response Categories	Percentage %
Discrepancy	65.4%
Cool	18.6%
Visually stimulating	16%

As can be seen in the table, the three response categories include 'Cool', 'Visually Stimulating' and 'Discrepancy'.

As described previously, the hooks were the dominant vehicle of interest within the interventions. Such a finding corroborates the development of situational interest observed in design cycle 2. Moreover, the results in table 8.4 corroborate the knowledge gap model hypothesised previously as the foundation of the triggered and maintained phases of situational interest. The largest category, 'Discrepancy' directly aligns with the observed reaction in that the hooks revealed a knowledge gap in the students' cognitive schema and thus developed situational interest. A large number of students would describe the phenomena in the hook and then note how the new information caught their interest. One student remarked, in relation to the hook about friction;

Q 1. What was the most interesting thing/part of today's science class?

I thought it was really interesting when we saw what the lubricant oil can do to make the knife slide out easily.

Q 2. Why?

It was something I'd never seen before and didn't know lubricant oil could be used for it. (Exit Card ECD216)

Another noted the following pertaining to the conservation of energy hook;

Student: *This was interesting because I knew it was new and something that I didn't know about before because I didn't know what would cause it. (Exit Card ECJ216)*

Chapter 8: Design Cycle 3

Another pair of student exit cards are presented below. In this instance, the students directly point to the part of the video they found most interesting. They identify the discrepancy within the video and mention how the material is new and novel to them.

Q1. What was the most interesting thing/part of today's science class?

The most interesting part was when the can started spinning.

Q2. Why?

Because I had never seen that before. (Exit Card ECE116)

Q1. What was the most interesting thing/part of today's science class?

The most interesting thing was about how the can began to move.

Q2. Why?

It was good because I didn't know that a gas would cause it to move, because it couldn't store anymore. (Exit Card ECE116)

The video in question is the energy conversions hook in which a steam engine is constructed from a can. Students are asked at the beginning of the hook, "How can you turn chemical energy into kinetic energy?". A blowtorch is used to heat the engine and create kinetic movement. Within the overarching hook design, the moment that the can starts to spin represents the discrepant event and encompasses the discrepancy design strategy. The fact that students pointed to this directly reinforces how the design of the hooks is realised through the development of a knowledge gap. This is further evidenced in the discrepancy response category whereby students describe the phenomena within the hook and explain the inconsistency in the video, based on their perceptions and prior knowledge.

Q1. What was the most interesting thing/part of today's science class?

The most interesting thing was how in the video, the rice stuck together and the knife created pressure at the end.

Q2. Why?

I thought this was interesting as at the start of the video, the rice acted like a liquid as when poured it flowed over itself but when the knife was inserted it would not budge or let it out. (Exit Card ECJ316)

Another student asked;

Student: *How can a ruler keep up a hammer?* (Exit Card ECJ116)

While another described the process involved in the atmospheric pressure hook;

Student: *It was cool how the cold water pushed into the can when it was full of hot water. The can squished up.* (Exit Card ECB116)

In the instances above, students vividly describe moments in the video in which a discrepant event occurred and an unexpected result ensued. The wealth of evidence suggests that the hooks revealed a knowledge gap in the majority of (65.4%) students' minds, leading to a triggering of situational interest. At this juncture, the basic components of hook impact model from design cycle 2 have been reinforced. They are displayed in figure 8.5 below.

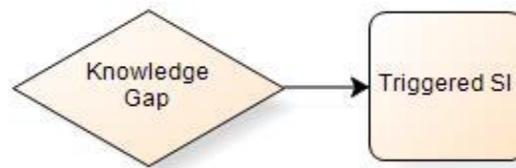


Figure 8.5: Hypothesised model of a knowledge gap creating triggered situational interest in design cycle 3

8.3.3 Fine Lines: Traversing the Blurred Boundary between Confusion and Interest

The former model (figure 8.5) and the results of the exit cards, although lending credibility to results in design cycle 2, present a simplistic view of the classroom environ. To garner a richer view of the process that instigated the student reaction to the hook, the following writing will partake in a closer examination of the group interviews and teacher journals to further illuminate the results thus far.

The six group interviews (Morgan 1996) with the students provided a level of context pertaining to both the teacher journals and the exit cards. Group interviews add considerable amounts of depth and richness to data in an efficient manner (Denscombe 2014, Frey and Fontana 1991). Throughout the group interviews, a convergence appeared between design cycle 1 and 3. Although pedagogically variant in terms of the scaffolding present in design cycle 3, the initial student reaction to the hooks was the same in both cycles, that of confusion. This presents and

ambiguity between the exit card results in the current phase and student opinion from the group interviews. This result will be delineated thusly.

In design cycle 3, at the beginning of the group interviews, students were shown one of the hooks as an icebreaker, the first question then asked them about their opinion and experience with regard to the hook videos they had been shown over the previous months. They recalled the hook videos with ease. In all six group interviews, the consensus from students was that the videos were ‘confusing’ as evidenced below;

Hanna: *“I was mostly confused with it.”* (Group Interview GID116)

Mary: *“It’s cool seeing it an all and seeing how it’s done, but like without the explanation, it can kinda get confusing.”* (Group Interview GIJ216)

Such sentiments were consistently expressed by students and aligned with similar results that emerged in design cycle 1 in which confusion was observed among the student body. So the question arises; if the students were confused by the hook at the start of the lesson, then why do the student exit cards present the videos as the dominant feature in relation to interest? Further examination of the students’ initial affective and cognitive state revealed that rather than simply being confused, students were intrigued and often wanted to resolve their confused state to understand the video hooks.

Alex: *“Just confused but like amazed by it. You know when the hammer was like with the ruler? Was that tied onto the ruler? it was a bit confusing.”* (Group Interview GID116)

Áine: *“...it was confusing when you didn’t know what happens so like so it made you think and think of why it happened.”* (Group Interview GID116)

Jennifer: *“...there weren’t any explanations which led us to think.”* (Group Interview GID216)

Some students, even directly, noted how the video presented a discrepant event and it didn’t agree with their developed sense of the world, lending weight to the knowledge deficit model.

Sylvia: *“Like so the friction one, that when you put the rice...”*

Chapter 8: Design Cycle 3

Researcher: *“The knife in the rice.”*

Sylvia: *“Ya, like I wouldn’t have thought it would have done that, I thought it would come out and I also thought when you put the oil on it, it was still gonna stick in...”* (Group Interview GID216)

Bill, one of the teacher participants noted the following;

Bill: *Students were challenged by the hook, especially completing what they saw on screen. Some believed it was magic.* (Teacher Journal TJB116)

As can be seen in the data, students were not just simply confused. Certainly the evidence presented above demonstrates a level of cognitive engagement (Zhu *et al.* 2009) with the video content along with a self-awareness pertaining to their own perceptions and understanding. Indeed, as noted in the previous chapter, it can be posited that the revelation of a knowledge gap can be related to confusion, in this instance, eventually giving way to augmented levels of cognitive engagement as Denise noted in her teacher journal that;

Denise: *Some intelligent questions [were] asked after the video.* (Teacher Journal TJD316)

James noted how students interrogated the content of the video, contending that rice cannot act as a liquid, a phenomenon displayed in the friction hook.

James: *Students took up the point of rice acting as a liquid and we used that as a starting point for friction in fluids.* (Teacher JournalJ316)

A student in one of the interviews alludes to the design of the videos as an instigator of cognitive engagement.

Researcher: *“Would the video make you think about physics?”*

Jim: *“Well those videos would because it kinda says at the end em, ‘how do you think this happened?’”* (Group Interview GIJ216)

A quote that was utilised previously is displayed below. Hanna demonstrates her cognitive engagement with the energy conversions hook.

Hanna: *“...with the like, the can, there was like 3cm of straw and like, what would it be like if it was 8cm or something like that?”* (Group Interview GID116)

As can be observed in the data, students were confused with the content, but wanted to make sense of what they had seen. As such, they questioned and probed the content with the help of the teacher and the exploratory pedagogy utilised in this design cycle. Indeed, this evidence presented here and the former exit cards (8.3.2) describing the exact discrepant events that triggered the students' interest in addition to learning new information they hadn't encountered before, belies a scenario in which students become cognitively engaged with the hooks to resolve the conflict presented by the apparition of a knowledge gap. Rotgans and Schmidt (2014) posit that the occurrence of a knowledge gap is dependent on an individual becoming cognisant of a new problem. In the case of design cycle 3, the new problem created confusion and intrigue (cognitive engagement) in the learners' minds. However, in accordance, numerous authors state that the arousal of a knowledge gap can be an 'unpleasant' (Jirout and Klahr 2012) one accompanied by feelings of deprivation (Rotgans and Schmidt 2011) and uncertainty (Litman *et al.* 2010). At this point, the evidence would suggest that a typical intervention in design cycle 3 starts from a position of confusion leading to cognitive engagement, which at some point during instruction turned to triggered and maintained situational interest. The confusion that arose in the third design cycle was contextually coupled to the lesson as opposed to peripheral confusion that is induced by misplacing a book for example. In a classroom context, Dowd *et al.* (2015, p. 1) asks "Can confusion be productive?". Confusion is defined as a state of triggered cognitive disequilibrium (Andres *et al.* 2014) or conflict that arises from contradictions, conflicts and discrepant events (Dowd *et al.* 2015, D'Mello *et al.* 2014). Discrepant information, defined by D'Mello *et al.* (2014) as a conflict or mismatch with prior knowledge. Confusion is the expected reaction from a discrepant event if a mismatch between prior knowledge and incoming knowledge is not resolved in the immediacy. However, confusion can be positively associated with learning due to a learner, in a motivated state, placing extra cognitive emphasis on the discrepancy and endeavouring to traverse the intellectual impasse. As such, it requires an individual to 'stop and think' before progressing, a situation described by D'Mello *et al.* (2014, p.154) as "desirable difficulties". Given this, there are two major learner pathways pertaining to confusion, confusion that leads to engagement and confusion that leads to disengagement. Students at this juncture have a choice, to attempt to resolve their confusion by placing more effort into their work or to give into frustration, boredom and disengagement (Andres *et al.* 2014). When confusion is unresolved, it has a large negative impact on performance (Bosch *et al.* 2013). Given this, it is advised that a confused student should be guided with clues and

support to benefit learning (Andres *et al.* 2014, Bickford and Bickford 2015). At this juncture, the researcher posits that in design cycle 1, the hook, as an isolated form of pedagogy not connected to the remainder of the lesson, created a confused state amongst students, one that was unresolved and led to disengagement. However, in design cycle 3, the same initial confusion emerged, yet, students worked with their teachers to resolve the confusion and by the end of the lesson were engaged and interested in the learning context. This argument is supported by the data;

Q 1. What was the most interesting thing/part of today's science class?

When the teacher explained.

Q 2. Why?

Because before, just when we had finished the video, I hadn't understood the video. (Exit Card ECD116)

Q 1. What was the most interesting thing/part of today's science class?

Answering the questions.

Q.2. Why?

So I could know what they are and learn more about them and actually understand the video. (Exit Card ECD316)

In these exit cards above, the students explain how they found the video confusing and indicate that the single most interesting part of their respective lessons was when the teacher explained the discrepancy in the video or throughout instruction, that is, by answering questions. These moments are potentially when the students' interest was triggered. Emergent in the data is a blurred or opaque boundary between confusion and interest, one that is mediated by pedagogy. Silvia (2008) describes a 'see-saw' effect pertaining to interest and confusion. The author states, "New and comprehensible works are interesting; new and incomprehensible things are confusing" (Silvia 2008, p. 58). Novelty requires comprehension and understanding is the difference between interest and confusion (Silvia 2008), a sentiment encompassed by the student's reaction above. The integration of the hooks into the lessons in design cycle 3 and the development of situational interest is contingent upon pedagogical exploration after viewing the hook. In this way, the hook is not an isolated feature of instruction, rather a key element in the learning process, one that students recognise as important and engage with through instruction. If one examines the pedagogy utilised by the teachers, this becomes apparent. They utilised the hook as a vehicle for IBL, think

Chapter 8: Design Cycle 3

pair share and driving questions. Through the pedagogy, the students' cognitive conflict becomes resolved and their interest triggered, albeit more consistent with a gradual triggered situational interest at various time points during the lesson rather than an immediate impact as observed in the second design cycle. The teacher journals also support the gradual triggering impact. In Bill's first lesson, he describes the student initial reaction to the hook as a "cool, hands off reaction" (Teacher Journal TKB116), but continued to state;

Bill: *They engaged far better as they were trying to complete the experiment and used the hook as a reference.* (Teacher Journal TJB116)

In the next lesson, he stated;

Bill: *More than 50% of the students were engaged at the start of class in anticipation for the experiment. Anticipation and engagement levels increased steadily as the class progressed.* (Teacher Journal TJB216)

In his third and final intervention, he notes;

Bill: *Over the course of the 3 hooks, student engagement has increased massively, from 30% to 90% plus. There is an anticipation to running the hook. There is an enjoyable atmosphere in the class when the hook is being run (played).* (Teacher Journal TJB316)

The evidence legitimates and supports the argument that the students' interest was triggered gradually throughout instruction. Moreover, the evidence would suggest that students became familiar with the teaching methods and thus the confusion they experienced when watching the video was not a concern, since they knew that firstly, this was normal based on their previous experience, and secondly that their confusion would be resolved throughout the lesson. Hence, at the end of the lesson, the majority of students indicate that the hook is the most interesting part of their lesson, even though their initial reaction was one of confusion.

With this, a layer of complexity can be added to the current hypothesised hook impact model. Expanding on the triggered facet of situational interest, both confusion and cognitive engagement facilitate the student reaction (figure 8.6).

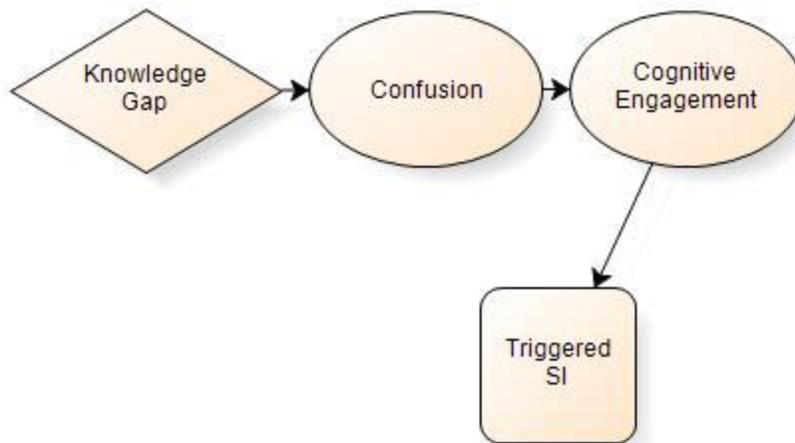


Figure 8.6: Hypothesised hook impact model with confusion and cognitive engagement

8.3.4 Persistence and Positivity: Maintaining Situational Interest

Based on the results thus far, the argument can be constructed that situational interest was not only triggered, but maintained throughout the lesson and in some cases beyond. Indeed, mirroring the previous iteration, design cycle 3 displayed evidence of maintained facets of situational interest.

“Maintained situational interest refers to a psychological state of interest that is subsequent to a triggered state, involves focused attention and persistence over an extended episode in time, and/or reoccurs and again persists” (Hidi and Renninger 2006, p. 114).

Based in the definition of maintained situational interest above, the case can be put forward that the student interest in design cycle 3 was both triggered and maintained over an ‘extended episode of time’. Although the definition is vague to a point, by interleaving evidence it can be demonstrated that students displayed behaviours associated with maintained situational interest over varying time periods. The first piece of evidence is that the exit cards were presented to students at the end of class. As noted, the results indicate that the majority of students describe the video hook as the most interesting aspect of instruction. Therefore, upon the triggering of situational interest at some time point of the lesson, the students’ interest was maintained until the end of class, potentially due to their cognitive engagement with the content. This may not represent an extended period of time, but does indicate that the situational interest in science class was

maintained throughout the duration of the lesson. Additionally, other evidence suggests that interest was maintained beyond the lesson. James, one of the teacher participants, reported that;

James: *Three students tried the knife and rice experiment that night.*
(Teacher Journal TJJ16)

In this instance, the video has created a maintained situational interest that lasted beyond the lesson and classroom. It also demonstrates students willingness to re-engage with the content, a core facet of maintained situational interest (Hidi and Renninger 2006). Bill adds to this as he describes the student reaction to one of the hooks.

Bill: *Students repeated the fork and spoon part over and over, taking pride in completing it. Some wanted to have another go at the hammer/ruler in the next class.* (Teacher Journal TJB16)

In this excerpt, Bill describes a scenario in which the students interest was maintained for an even longer period of time. Students wanted to attempt to re-engage the phenomena in the video in the following lesson (Hidi and Renninger 2006). As such, their interest was maintained for at least a day. Moreover, a fundamental indicator of maintain situational interest is that of persistence (Hidi and Renninger 2006) and this is evidenced in both of the previous quotes.

Additional evidence, from the group interviews, would suggest that the students' interest was maintained. When conducting the interviews, the researcher asked the students, which of the hook videos they had seen. Without hesitation, the students recalled the three hooks that the teacher had used in class over the four-month intervention period. They couldn't remember the titles of the videos, but could describe what happened. A typical description by one of the students is presented below;

Tommy: *"You know the one with the balloon where you pop it, there's like a bed of nails..."* (Group Interview GIB216)

Another student, Hanna, recalled the energy conversions hook and asked about the length of the straws in the video.

Hanna: *"...with the like, the can, there was like 3cm of straw and like, what would it be like if it was 8cm or something like that?"* (Group Interview GID116)

Indeed, situated and exemplified within the researcher's reflections was that the students' knowledge and memory recall pertaining to the hooks was excellent.

"They had some insightful moments, again, they had a great understanding and memory of the videos." (Reflection RRJ16)

The students recall was a surprise to the researcher and to teacher participants who intimated that they felt the students would not remember the videos. Yet, the data strongly points to a persistent and maintained interest that lasted for months in some cases. Given this, the hooks represented a focal point in the students' memory, which in turn is an indicator of maintained situational interest (Flowerday *et al.* 2004, Hidi 2006).

The final piece of evidence that supports the maintenance of situational interest is the 'Cool' response category from the exit cards. 18.7% of students remarked that the video hook was the most interesting part of instruction because it was 'cool'. In general, students provided no more context, however, the argument can be constructed that if the video hooks are 'cool', then they may represent a meaningful part of the students' instruction, one that they valorise through the use of colloquialisms. As described previously, meaningfulness is a contributor to the maintenance of situational interest (Hidi and Renninger 2006, Magner *et al.* 2014, Mitchell 1993). Hidi and Renninger (2006) state that positive feelings are associated with maintained situational interest. Moreover, they note that the early phases of interest development (triggered and maintained situational interest) can be readily identified by affect in or liking of content or context (Arnone *et al.* 2011, Hidi and Renninger 2006, Köller *et al.* 2001). With the strong 'cool' response, it can be postulated that students had a maintained interest in the hook content. Given the results, it is positioned that the knowledge gap hypothesis, concomitant with the triggering and maintenance of situational interest is supported by the exit card data in design cycle 3.

Based on an amalgamation of the data presented above, the knowledge deficit model in design cycle 3, with a new instructional approach can be fully depicted (figure 8.7). It incorporates the maintained facets of situational interest including persistence and positivity.

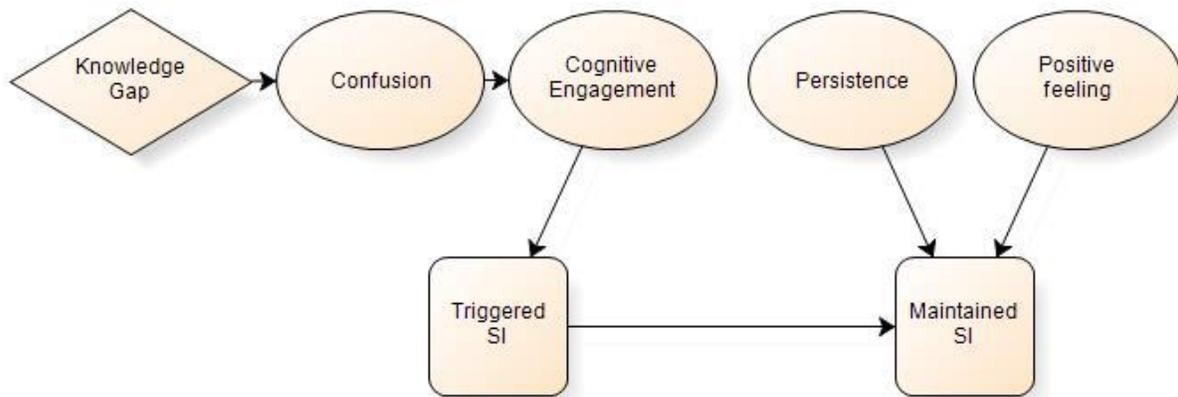


Figure 8.7: Student impact model for design cycle 3

Interleaving the various forms of data in the third design intervention, the research has arrived at figure 8.7. As in the case of the previous hook impact model, it is comprised of various phases, in this instance three. In a similar vein to the previous model, the foundation is built upon a knowledge gap associated with triggered and maintained situational interest. However, the immediate reaction to the hook is different. In the previous model, the immediate reaction was one of emotional engagement and attention. Triggered situational interest was instantaneous. However, in the above model, confusion and secondarily, cognitive engagement are the immediate reaction to watching the hooks. An intriguing component of the model is the initial confused state of the students and whether or not confusion can be defined as a form of emotional engagement. D’Mello *et al.* (2014) underscores that confusion is an affective state. Hence, drawing the lines between the models even closer, the major differentiator being that the emotional engagement in design cycle 2 was positive and varied, whereas in design cycle 3 was seemingly more negative, uniformly defined as confusion. With regard to the maintained facet of situational interest, in this phase, it was defined by evidence of persistence from the students and positive feeling as derived from the ‘cool’ response category from the exit cards. This positive feeling may in fact denote that the hooks represented something that was meaningful to the students by the end of instruction, similar to design cycle 2, however, one variance is that cognitive engagement represented a maintained facet in design cycle 2 rather than a triggering facet in design cycle 3.

8.3.5 Pedagogy as the Hinge in Differentiating the Student Impact

As is readily observable in this chapter, the differentiation between the hook impact models in

design cycle 2 and 3 hinges upon pedagogy and hook placement. In design cycle 2, the para-hook is grounded in prior knowledge development and preparation. This was fundamental to creating interest. However, in this phase, pedagogical choreography in the form of instructional exploration of the hook is warranted in order to create interest. Both models are situated in pedagogy and emergent from their context. In design cycle 2, the discussion positions the student reaction to the hooks, that of interest derived through the revelation of a knowledge gap, as one that is experienced by the majority of students based on observational data. However, in design cycle 3, the most modest estimate is that 31% of students place the hook as their most interesting aspect of instruction with the potential for this to rise to 53% based on students who regard the video as the most interesting and those where it could not be delineated whether the video or practical elements of class were most interesting.

As a deviant example, one teacher in design cycle 3, Eva, used the video as a para-hook. The teacher conducted practical work and then played the hook with a segmentation strategy. Through an examination of the student exit cards, the results demonstrate that 54% and 8% (62% combined) of students in this class state that the phenomena in the video and the video as the most interesting aspects of the lesson respectively. For the rest of the interventions, in which the hook was used as the lesson introduction, 31% and 13% (44% combined) of students in this class state that the phenomena in the video and the video as the most interesting aspects of the lessons respectively. The limited amount of data demonstrates a differential of approximately 18% and could be an indicator that para-hooks created more interest among students. Thus, lending credence to the recorded student impact in the second design phase among the majority of students. However, there is not enough data to make a credible assertion. This is something that could be examined with further research comparing both pedagogical approaches in the latter two design cycles, preparation and exploration.

Design cycle 3, acted as a confirming intervention that also allowed for further exploration of the hooks in situ. Even through teachers implemented a different type of pedagogy, varying the student response, the former results have been compounded through triangulation and multiple interventions. The physics video hooks, when integrated into a lesson, reveal a knowledge gap among the majority of students leading to the development of situational interest.

8.4 Chapter Summary

This chapter has analysed and presented the results of the third design cycle in which a capstone phase supported the preceding design interventions. Previous findings, such as the development of a knowledge gap concomitant with situational interest have been reinforced and substantiated with a diverse array of confirming evidence. Conversely, new findings pertaining to the implementation of hooks and the associated impact on students have been uncovered. The next chapter will present a discussion of findings pertaining to the three design cycles while encapsulating the simultaneous advancement of hook theory and design.

Chapter 9: Findings and Conclusions

9.1 Chapter Introduction

This thesis has explored a new type of educational technology, video hooks and by extension, para-hooks, by interleaving theory, design and practice. The fulcrum of Design-Based Research is the simultaneous advancement of theory and design with naturalistic contexts acting as catalysts for change (Dede 2005). The prototype hook design artefact has been implemented and tested through a vigorous narrative to produce robust modifications and research outputs in the form of frameworks and processes. The physics video hooks intervention process has been implemented in such a manner that it supports teachers, technologists, educational designers and researchers to enhance interest and engagement among students through the use of digital media and pedagogical innovation.

This chapter will firstly summarise the thesis structure and then demarcate the evolution of design throughout the project with a finalised framework mapping the successful implementation of video hooks in the science classroom.

9.2 Pedagogical Contribution

It is postulated that this research has made a significant pedagogical contribution to knowledge pertaining to the implementation of hooks and para-hooks. Within the wider literature, implementation methods or instructional guidelines for educators are scarce. In terms of hooks, the majority of literature presents the ideology that they are an instructional method employed at the beginning of instruction. For the type of hook presented in this research, one that is derived from literature, it can be stated, with caveats, that utilising the hook during the lesson introduction as an isolated pedagogical approach is ineffective. That is, a hook needs to be incorporated into the wider instruction of a lesson to be effective. As a solitary event, distinct from the rest of the lesson, it provides no benefit to the teachers or students per the results of design cycle 1, the pilot study. Indeed, a disjoint between teacher's pedagogical orientation, theory and design was revealed. The argument can now be presented that hooks require incorporation into the wider learning ecology, as a para-hook, perhaps as part of an instructional model or learning approach per their origins.

With a strong indication that pedagogical isolation is not an appropriate implementation strategy, design cycle 2 oscillated from a theoretical orientation to a practical one. Teachers were

asked, based on their pedagogical beliefs, to utilise the hooks how they deemed appropriate. Working with teacher participants, a fundamental concept of DBR (Alghamdi and Li 2013), their practical orientation to both technology and hooks came to the fore. In this instance, pragmatism was the key worldview that determined the implementation of the technology. From this standpoint, teachers no longer viewed the videos as hooks, rather, as instructional, revision and inquiry based videos, the foundation of para-hooks. The hooks represent an adoptable and adaptable piece of educational technology that can fulfil a number of roles within the classroom. Teacher pedagogy reflected this and the hooks were implemented in a variety of fashions. This is particularly important in terms of the instructional implementation of video as Wang (2014) accentuates its weak theoretical foundations. The current research output demonstrates how video and hooks can be incorporated into pedagogy with a variety of techniques, as para-hooks, substantially adding to the current theoretical base of hooking. It also justifies further research into video classification and implementation methodologies. With the current video hooks however, the communal aspect to pedagogy was the placement of the hook in the middle or toward the end of the lesson. The teacher participants placed a focus on the development of prior, running or experiential knowledge. The para-hook represented a fundamental focal point of the lesson whereby teachers layered their teaching strategies (eliciting knowledge, skill and attitude) in an incremental way towards the revelation of the video. This preparation phase, enabled a 'show and reveal' process in which the teachers developed a particular scientific worldview among the students and by playing the hook, a video displaying a discrepant phenomenon, it deliberately conflicted with the established content of the lesson. The hook was a 'payoff' for the work that led up to that point. The videos contain scientific phenomena linked to the syllabus, and without prior knowledge it is difficult for students to cognitively negotiate the content without the correct frame of thinking. With the development of prior knowledge, however, the reaction from the students was one of interest and engagement due to the revelation of a knowledge gap in their cognitive schema. Implementation of the para-hooks proved effective for both teachers and students. At this point, the results align with McCrory (2011) who states that hooks should be placed at any point of instruction as the development of interest and engagement in science provides long term benefits to teaching and learning. Yet, the results of this thesis not only indicate that hooks need to be incorporated into the wider learning context, in this cycle as para-hooks, but has delineated numerous effective instructional methods such as IBL, segmentation and pre/post strategies. Given

this, the discrepancy based hooks can fulfil several roles in class, such as revision or consolidation of learning. Although the hooks represent an immutable design, their open-ended nature enabled their reflexive incorporation into the learning content by allowing teachers freedom with a design artefact often described as a ‘multi-tool’. This highlights the supporting role that technological resources can play in the classroom. With the para-hooks, the teacher remains in control and decides the pace of learning. The technology bolsters the teacher’s pedagogy rather than dictating it. This demonstrates the importance of teachers designing for teachers and the local context in technology driven learning environs, as was a fundamental feature of this research.

At this juncture, the research moved onto design cycle 3, whereby the hooks were again tested in situ with a sub-group of teachers from design cycle 2. The results of the former phase were imparted to the teacher participants and they were asked to repeat the para-hook instructional techniques that they utilised in the former phase. However, throughout this cycle, the majority of teachers changed their pedagogy and placed the hook at the beginning of the lesson. Again, this highlights the teacher participant’s philosophy. As their needs and aims change, so does their pedagogy. Science teacher’s pragmatic application of technology is based on their interpretation of context and the complexity of their classrooms. Furthermore, their understanding of the hooks, as a pedagogical and technological resource, was continually developing. Due to this, and the open-ended design of the videos, teachers again implemented the hooks in a variety of fashions, mainly as an opening driver for inquiry based approaches. The bespoke styles highlighted the provenance of the hook as a ‘multi-tool’ enabling an ease of use and incorporation into the science classroom. However, as can be derived from design cycle 1, employing the hooks as the lesson introduction was ineffective with students becoming disengaged. Yet, in design cycle 3 students became engaged and interested in the videos, more specifically the discrepant phenomenon displayed. The major difference between the two cycles is that in design cycle 1, the hooks were used as an isolated event, without consideration of prior knowledge and without reference again during the lesson, conversely, in design cycle 3, the teachers explored the content of the hooks as the pedagogy of the lesson and the video content were intertwined. The emergent response from students was confusion in both cycles, however, in design cycle 3 the confusion turned to cognitive engagement, as the teacher drew out student understanding and eventually interest that lasted for the remainder of the lesson.

In sum, pedagogical isolation (hook), preparation (para-hook) and exploration (hook) exemplify the three teaching strategies that have emerged through teachers' interrogation of hook pedagogy from both theoretical and practical origins. In this research, with a focus on the development of student situational interest, with the acknowledgement that a hook cannot remain an isolated part of a lesson. Hooks need to be incorporated into the wider pedagogy, not as an isolated event, but rather a focal point, which a lesson can be built around. Intrinsically, the learning environment becomes interest driven. If a hook is used in a more traditional sense, as derived from instructional models and the consensus definition, then a pedagogical exploration phase is warranted following the video hook. However, when the hook is used at another time, point during the lesson, a preparation phase is warranted to 'build up' to the hook. By extension, this new methodology is a para-hook. This new knowledge makes a significant contribution to theory as existing stances on hooks have been advanced and practical advice to educators developed. Moreover, the associated impacts with each instructional strategy vary to a point, but also have a lot of overlap. Such impacts will be elaborated upon in the following section.

9.3 Theoretical Contribution

A substantial theoretical contribution of this research is the conceptualisation of both interest and engagement in a hook based context. Significantly, Renninger and Bachrach (2015) discuss the theoretical overlap between interest and engagement in school based settings and note that the constructs' conceptualisation and description from authentic classroom settings are scarce. This research, with three design cycles has illuminated two separate syntheses of interest and engagement in class, revolving around pedagogical variance.

A fundamental core of both models, hook and para-hook, is the creation of situational interest in class. As a baseline, interest was triggered and maintained when preparatory and exploratory phases were utilised in association with the physics video hooks. Furthermore, emergent from the findings was the development of a knowledge gap among students, the motivator for interest development in class, a result that resonates with the core discrepancy design element embedded in each of the physics video hooks. For this reason, the knowledge gap is the vehicle for interest driven behaviours.

In design cycle 2, the link between interest and engagement was overt and readily observable, in particular the apparition of triggered situational interest and emotional engagement,

concomitant with augmented and instantaneous attention levels (Linnenbrink-Garcia *et al.* 2010). This immediate response to the hook was easily recognisable in class with students verbally expressing their awe, wonder and disbelief while physically expressing their need to get a better view of the screen and socially interact with their peers. This reaction gave way to a more controlled cognitive engagement with the hook content, comparative in this instance with a maintained situational interest. The model below (Figure 9.1) represents a significant contribution to theoretical and practical thinking in terms of interest and engagement development in a hook based setting. Fundamental to the reaction described was the development of a knowledge gap among the student body, something that was reinforced in design cycle 3.

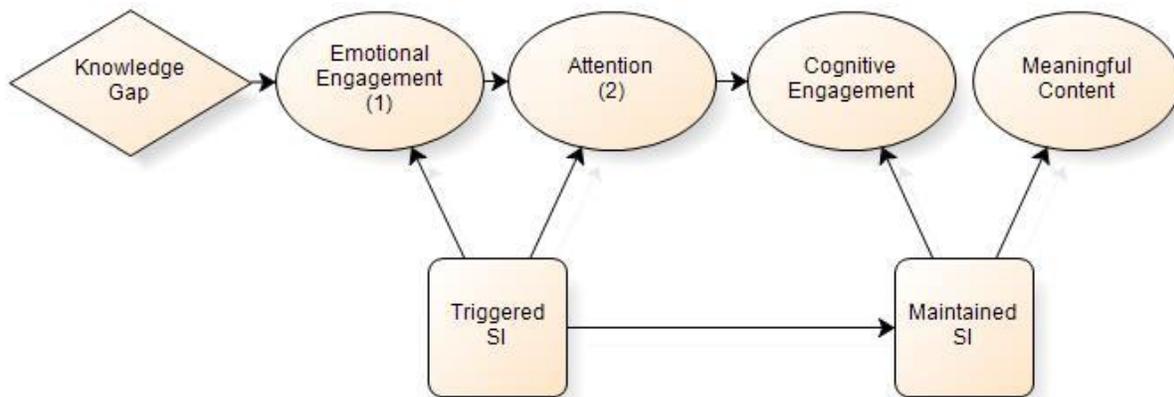


Figure 9.1: Para-Hook impact model derived from data in design cycle 2

In the third hook intervention, the results of the former phase gained credibility, as again students interacted with the hook based content. Central to the student reaction was situational interest founded upon the revelation of a knowledge gap. Exemplified by this result, it was apparent that even though the pedagogy in third phase differed from the former, students need to interact with the hook in a meaningful instructional manner, recognise the discrepancy in the hook and attempt to resolve that discrepancy throughout the lesson. However, due to the instructional differences between the cycles, the impact of design cycle 3 was unique to some degree. In both the first and third design cycles, the hook was used during the lesson introduction and without prior knowledge or context, the students' initial reaction was that of confusion. However, within the literature it is noted that students, upon becoming confused, choose between two pathways, disengagement or engagement (Andres *et al.* 2014). In design cycle 3, due to pedagogical

exploration of the content, students became engaged with the content. Their confusion, which can also be described as a form of emotional engagement (D’Mello *et al.* 2014), giving way to intrigue and cognitive engagement. At some stage during instruction, their interest was triggered in what seems to be a gradual impact as students garner more knowledge and understanding to identify the interesting aspects of the hook content (Figure 9.2), which is in stark contrast to the immediate impact of design cycle 2. As such, the students demonstrated a situational and scientific interest (an interest in science) that was maintained until the end of the lesson. This marks another significant finding of the thesis pertaining to the how instructional variance can have such a strong impact on interest and engagement development. In design cycle 2, students were given all the ‘cognitive tools’ to negotiate the hook, hence the immediate reaction. In design cycle 3, students had to cognitively negotiate and figure out the content, per the gradual, trickling reaction in class.

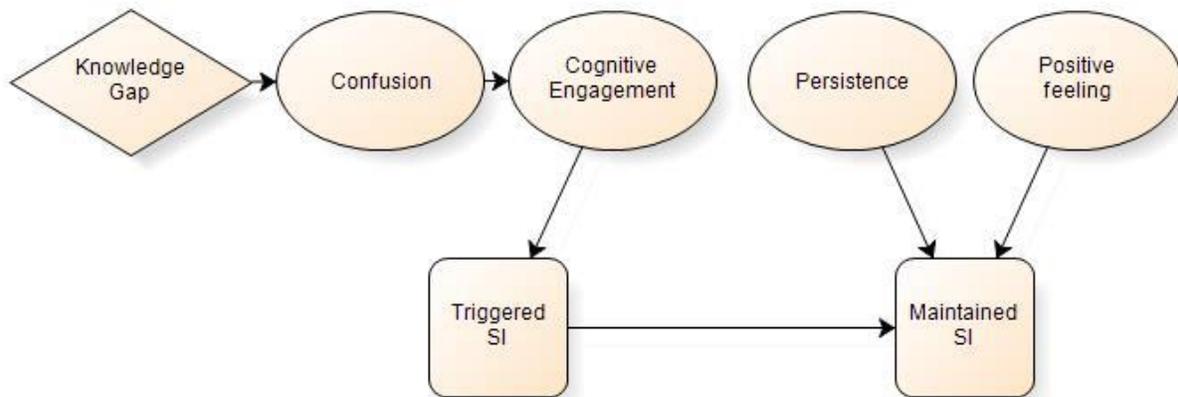


Figure 9.2: Hook impact model for design cycle 3

Additionally, the theory developed in relation to the constructs of interest and engagement are designed to be readily observable by educators, easy to follow and potentially cultivate in educational contexts. The main driver behind this is that DBR “must do real work” (Cobb *et al.* 2003, p. 10) in real classroom environs, rather than being so theoretically laden that designs are only of use to the pigeonholed few (Renninger and Bachrach 2015). Yet, it can be argued that the models and simple descriptions provided are of use to educators, whereas the ‘thick’ descriptions provided in the design chapters with the minutia of detail can be interrogated and advanced by researchers. Coupled, they represent specific outcomes of design and implementation, in particular when the design is grounded in a discrepancy based approach. Indeed, much of the discussion

pertaining to the findings and conclusion revolves around the hook design. Produced in digital video format, the design heavily impacted upon the pedagogy and the student impact. The various design elements and strategies associated with the theoretical and practical parts of the study will be fully articulated in the following writing.

9.4 Design Contribution

One of the largest contributions of the current research is in relation to the creation of hooks and the enactment and verification of numerous designs. With specific reference to design strategies operating in combination to enable adoptable and adaptable pedagogy with multifaceted impacts upon students, something that is achieved through a static design, wholly grounded in the needs of classroom stakeholders. As previously described, the hooks developed situational interest among students through the revelation of a knowledge gap. Findings throughout all the interventions suggest that the reasoning behind this reaction was the discrepant phenomenon featured in every hook. Students could readily identify the discrepant moment and their reaction, whether it be confusion, interest or engagement was predicated upon their interaction and cognitive appraisal of the instances in which discrepancy is exhibited. Certainly, it seems that students sought out discrepancy wherever possible. They appeared to enjoy watching and discovering new and novel information. An instance of which is when James, one of the teacher participants, played a video in class demonstrating how a person can run on custard, a discrepant demonstration that garnered the students' interest, a result reflected in the exit cards. Students indicated one of the main reasons for their interest was that they were encountering something they didn't know previously, moreover, they interacted with new information that conflicted with their conception of the world, revealing a gap in their knowledge, between their own perception and reality. In light of this, it can be postulated that fundamental to the research is a hooking strategy grounded in the demonstration of discrepant phenomena, not necessarily a new contribution to the literature as numerous authors discuss conceptual conflict/change as a method of interest development (Duit and Treagust 2003, Lee *et al.* 2003, Jones *et al.* 2015). However, it would be reductive to suggest that the discrepancy based strategy operated as a singularity. The novelty of both the design and the research is the combination of design factors that complement each other. Collated, the inherent design directed students to the point of discrepancy, so that it could be readily identified and thus, the student could interact with the content to varying degrees, mediated by pedagogy.

Chapter 9: Findings and Conclusions

This is obvious when examining the use of cognitive load principles (De Jong 2010, Mayer and Moreno 2003, Paas *et al.* 2003, Sweller 1994) and multimedia principles (Kalyuga *et al.* 1999, Mayer 2002, Mayer 2005, Mayer 2008, Sorden 2012) to create the open-ended hook design. Students can easily transverse the video introduction, the layout of materials and general set up. With this type of strategy, they are not bombarded with content they have to remember. The simple design builds up to the discrepant phenomena, so any student, regardless of ability, should be able to comprehend all the content until they reach the discrepancy. The discrepancy can be regarded as a trick, however, there is nothing hidden within the videos, all the materials identified and the procedures are easy to follow. As such, any individual with the appropriate knowledge can observe the video and identify the discrepant event. With this type of design, it is difficult to reduce the content without taking away from the experiment and potentially losing the visual flow and narrative. Pertaining to other design elements, the questioning strategy was used during the start of videos to get students thinking about their own perceptions of phenomena that would eventually be displaced by the discrepancy. In addition, the questions were used as a signalling method (Spanjers *et al.* 2011), guiding students to the point of discrepancy. In relation to the relevance design element, it aided the discrepancy as it utilised everyday objects wherever possible, thus creating an amplified conflict in the students' mind as they will have interacted with many of the items in the videos. For this reason, the contribution of the research is in the design of a piece of educational technology that creates a visually effective, balanced and synthesised discrepant event that is enhanced by an interweaved web of design elements and considerations. The evolution of which, was solely derived from the ADDE* instructional design model employed at the beginning of this project.

Important to the overarching contribution of this thesis was the utilisation of a modified ADDIE instructional model. The ADDE* model employed lacked an implementation step in the design process of the artefact, and instead, implementation was explored in the form of three separate interventions over the course of the three years that followed. Implementation, particularly in terms of educational interventions takes time due to the complexity of the classroom, individual contexts, numerous stakeholders and the practicalities of both schools and science classrooms (Herrington *et al.* 2007). The initial design of the suite of video hook artefacts however, took eight weeks to create and based on findings was very close to what was needed in the junior science classroom. Pertaining to the hook design, participant feedback highlighted minor

critique that resulted in the removal of two hooks from the suite following design cycle 2, as deviant examples. There are a number of possible reasons for the initial successful design. Firstly, the design was focused on the Irish syllabus. The amount of video content that is tailored for the Irish junior science syllabus is minimal, hence, the teachers liked the hooks and noted them as highly relevant tools ready to integrate into their teaching. The design was by teachers for teachers, and this was evident throughout the research in terms of the videos aligning with the curricula and providing novel visualisations for inquiry based approaches. Secondly, the design was open-ended and facilitated a variety of pedagogical styles and techniques. The video hooks only revealed some of the information, enough to draw the learner in, and as such gave control to the teacher in terms of the extended pedagogy chosen to expand and explore the concept and dictate the pace of learning. Given this, the ‘low-threshold’ video hook empowers the teacher’s personal instructional style or preference rather than limiting them.

In line with DBR, theory has been advanced pertaining to hooks, while design principles have also been tested and established. At this point, such findings can be extrapolated to other contexts with a good level of generalisability in the Irish context due to the variety of teachers involved with the research, the milieu of pedagogical approaches the diversity of students. With this, design elements can be incorporated into various instruction techniques, a typical example being that of a demonstration or experiment. Furthermore, the study has demonstrated that the hook can be placed in a variety of schools, bolstered by complexity and diversity. Hence, the current design can be ‘lifted’ and placed into another setting with a high degree of confidence. Moreover, the design can be ‘divided’ so that teachers and educational designers can pick and choose (Edelson 2002) sensitivities that fit their requirements.

9.5 Defining Hooks and Para-Hooks

Grounded in an amalgamation of the literature, the initial hook definition advanced throughout this research is that; A hook is a short instructional strategy utilised at the beginning of class to augment students’ attention (Hunter 1994, Lemov 2010, McCauley *et al.* 2015), interest (Jewett Jr 2013, Marinchech 2013) and engagement (McCrorry 2011, Riendeau 2013). In light of this definition, video hooks were constructed with the specific aim of targeting such constructs. Throughout the research narrative, it can be delineated that the current hook design does not seamlessly fit within the boundaries of the initial definition. Yet, the physics video hooks, although

labelled as multi-tools by teachers and employed for an assortment of pedagogical tasks, can be defined as hooks and para-hooks. They certainly targeted attention, interest and engagement, however, their implementation was not limited to the beginning of class, they did not operate as a singularity, and the generation of the former constructs was not without complication. Both issues will be discussed presently.

Firstly, pertaining to the placement of hooks at the beginning of the lesson, a hook caveat consistent with numerous authors, the results of the current research demonstrated not only that hooks do not have to be placed at the beginning of instruction, but their associated impact is more pronounced when they are used in the middle and toward the end of the lesson as para-hooks. Placing hooks at the lesson introduction is seemingly a vestigial remnant of instructional models, limiting hooks to a particular time slot. McCrory (2011) is the only author that advocates the utilisation of hooks throughout instruction. In essence, McCrory (2011) aims to promote learning environments that enable interest development at any stage and hence valorises such processes in the science classroom. The emergence of para-hooks reinforces the author's arguments, particularly in relation to the formation of interest and engagement. Conversely, the current thesis has also established that hooks can be placed at the beginning of instruction. Although it should be acknowledged that the associated impact is different from the initial definition. When the hooks were employed during the lesson introduction, the associated impact upon the student body was confusion, particularly prevalent in design cycle 1 and resolved in design cycle 3. With the design of hooks put forward in this thesis, the discrepancy in the videos caused confusion when the students did not have the appropriate scientific prior knowledge to fully grasp the content. As such, the initial reaction did not align with the aforementioned definition of hooks. In the third design cycle, pedagogical exploration of the content eventually led to the gradual development of engagement and interest. Emergent in the results is the requirement for pedagogical exploration when the hooks were used in a traditional manner derived from instructional models. The student reaction is also far more complex than simply stating that hooks impact upon attention, interest and engagement. The reaction described in this thesis is complex and contains a host of interwoven and multi-layered factors that are not in line with the former definition. The argument can also be constructed in terms of the triggered and maintained reactions of the students throughout the interventions. In all interventions, the video triggered students' interest and attention, but only with pedagogical accommodation through preparation and exploration was the students' reaction

maintained. Hence, with incorporation into a lesson, the value of the hook is augmented far beyond the shorter triggered reaction that doesn't necessarily benefit learning or instruction in the longer term if it is not maintained.

Given the arguments in the former paragraphs, the hook research carried out here does not align with the current consensus definition in the literature. Hooks warrant a definition that is fluid enough to accommodate various instructional approaches, time placement within the lesson, and the potential for a multifaceted impact on the student body. Grounded in the findings of this thesis, a hook can be defined as a focal pedagogical strategy that initially evokes affective and cognitive states among students, which throughout instruction, develops into maintained interest and engagement. And by extension, a video hook, in addition to above, incorporates a discrepant event, a knowledge gap, a deliberate confrontation that disrupts the learner's assumption of what should happen. In addition to the above, a para-hook is a short instructional strategy utilised to augment students' situational interest and engagement at various time intervals other than the lesson introduction. As such, it is an extension of traditional hook methodologies. It should be noted however, that the definitions presented are based on a specific design and a change in design could alter the definition. Per contra, the definitions, have enough specificity, while also being malleable to be of use to educators, researchers and designers.

9.6 Conclusion

9.6.1 Significance of Contribution

The research question initially set out in this thesis, 'How can physics video hooks be designed and implemented to generate student attention, interest and engagement in physics?' has been answered. With this, the contribution of the research is threefold.

Firstly, the thesis demarcates how hooks can be designed and modified throughout an ADDE* model and DBR processes. The design is such, that it can be replicated or dissected and placed into other research contexts. The current understanding of the physics video hook design is layered, in that design elements and strategies have emerged to take priority over others due to the design's interaction with the complexity of the classroom context. At present, the design is now informed by both literature and empirical evidence, lending credence to the numerous elements and strategies embedded within the hooks. Discrepancy has emerged as a fundamental design factor at the core of the student reaction. Other strategies enhanced and guided students toward the

discrepancy with cognitive load and multimedia theories directing the narrative of the hooks. As can be determined, the hooks were ‘cobbled’ together through an analysis of the literature. Given this, the significance of the design contribution lies in the sum of the parts working in tandem and evolving in the classroom context. The finalised design represents one of the contributions of the thesis. In addition, another significant contribution resides in the benefits of employing an ADDE* model in the construction of proto-design that was designed for teachers, by teachers. Moreover, the hook design framework can be used to inform numerous design projects from large scale visualisation software, computer programs and in class interventions.

The second contribution is in terms of hook pedagogy, something of which there was no empirical evidence to support, legitimate or mediate. Through the articulation of an interventionist DBR methodology, various hook implementation methods have been described. This is the first instance in which hook based instruction has been substantiated while encompassing practical saliencies. As Star *et al.* (2016, p. 1) notes “Education policy should aim to promote instructional methods that are easy for teachers to implement...”. The combination of design and teacher needs has demarcated incorporation methods for video (Wang 2014) and hooks into the science classroom in a multitude of fashions that are contextually transcendent in the Irish setting. A key addition to the current hook literature is the integration of the hook into the wider pedagogy of the class as a para-hook, rather than placing the hook as an island at the start of the lesson. This contributes to the new definition of hooks as described above in section 9.6.

Thirdly, the research describes a significant theoretical contribution with regard to the impact of the hooks on the student body. The impact hinged upon pedagogical accommodation operating in tandem with the design. The research tools enabled the conceptualisation and analysis of attention, interest and engagement in situ along with their convergences through the examination of the literature and evidence. By extension, the thesis adds to the literature around these three concepts and helps to clarify their difference as individual measurable concepts. A plethora of work has been conducted into the former constructs. Yet, this marks the first instance in which the constructs are assessed during hook and para-hook based instruction. Moreover, it also details the convergence between interest and engagement and how such a merging is contingent upon the type of pedagogical approach used in class. With this, the hook impact models

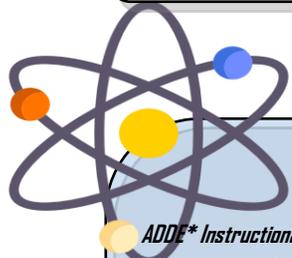
Chapter 9: Findings and Conclusions

from design cycle 2 (Figure 9.1) and 3 have emerged (Figure 9.2). Both models represent equally important contributions that are facilitated by pedagogical variance.

Over the course of the three implementations with the physics video hooks, their potential, particularly as a method to augment student interest and engagement has been demonstrated. The research originated at a precipice and has extended an intermediary subtended scaffold into other research domains. The novelty of the study is strengthened by the combination of design, implementation and impact. The journey in this thesis from a theoretically based design to one that has been shaped by research is demarcated in figure 9.3. It illustrates the distal bespoke contribution of the research. The model has been created to be of use to educators, designers and researchers. It recapitulates the writing of this chapter in relation to design, pedagogy and theory. It accentuates research's contribution to knowledge and theory as summarised above.

Chapter 9: Findings and Conclusions

Hook Framework



Design

ADDE* Instructional Design Framework

Process of collaborative design, research and creation between teachers to create hooks.

ANALYSIS

Context of the educational system

Student and teacher requirements in the classroom

Appropriate format (e.g. Video is suitable for dissemination and practical use)

Examination of strategies to garner attention, interest and engagement

DESIGN

Cognitive Load Theory (Open-ended design)

Multimedia Design Theory (If using digital media)

DEVELOPMENT

Planning and sequencing of content

Testing and refinement experiments and content

Discrepant phenomena are key

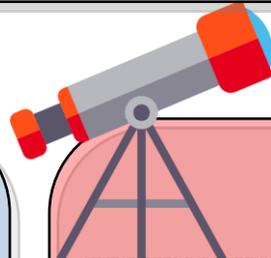
Questioning can be used to guide students

Use relevant examples and materials

EVALUATION

'In house' peer review

Flexible and collaborative design



Teaching

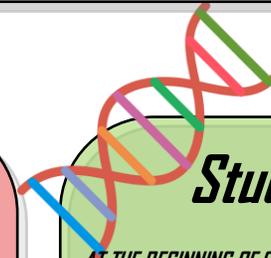
AT THE BEGINNING OF CLASS - Hook

The hook can be used at the beginning of class as a driver for inquiry. Often students will be initially confused by the discrepant event. Teachers should explore the content so that students further engage with the hook and resolve their cognitive conflict. This can be done through Inquiry based approaches, recreating the hook, group work, think pair share, driving questions and making predictions.

IN THE MIDDLE OR THE END OF CLASS - Para-hook

With this method, teachers need to 'build' up to the hook. By developing the students prior and running knowledge about the topic, students should be able to understand the discrepant event and recognise it as an anomaly. This will enable more of an immediate and interested reaction from the students. The hook can be used to consolidate learning, revise topics, check for understanding by using prediction, inquiry and group work strategies.

NOTE: Fundamental to the success of the hook is its integration into the structure of the lesson. Often the hook is a key focal point within instruction.



Student Reaction

AT THE BEGINNING OF CLASS - Hook

The hook reveals a knowledge gap among the student body with three phases. Students initial reaction will be one of confusion, however, if student continues to engage with the hook throughout instruction, they will become cognitively engaged and direct their attention to the part of the hook that confused them, often grounded in the discrepancy strategy. Students will become more intrigued throughout instruction and they will become more interested in the content. This interest will be maintained until the end of the lesson. This strategy will gradually trigger students interest throughout instruction.

IN THE MIDDLE OR THE END OF CLASS - Para-Hook

This strategy reveals a knowledge gap among the student body. Their initial reaction is a visible emotional engagement with the hook. This represents a triggered situational interest. Students will then become cognitively engaged with the hook and ask questions to figure out the phenomena. Student interest is maintained until the end of the class. This strategy will have more of an immediate impact and trigger the majority of students' interest at the same time.

Iterative and Flexible Design and Implementation

LOCAL CONTEXT

Design for context of the school and student makeup.

RESEARCH

Find the best hook strategies by researching and testing what works.

TEACHER NEEDS

Use the strategy that works and gets students engaged with the hook.

PRIOR KNOWLEDGE

The students' prior knowledge is key to their engagement.

1st OR 2nd YEAR CLASS

Hooks work best with younger year groups.

STUDENT NEEDS

Students will want the answers, but they should have to work for them.

Figure 9.3: Bespoke design model originating from this research 271

9.6.2 Recommendations for Future Research

The current research represents the initial foray into the design and implementation of hooks. With the results, a number of recommendations can be made for future research components that would add to the knowledge base.

As noted, a qualitative approach was instigated to allow for the open assessment of the hook impact upon students. However, now that the impact has been described and substantiated, the next research step is to move onto more quantitative assessments to critically analyse the impact of various teaching and learning sequences presented in this thesis. A quantitative assessment would provide confirming data over a wider variety of classrooms. With this, numerous variants can be applied. For example, longitudinal studies could be considered whereby situational interest could be measured over time in class, per Rotgans and Schmidt (2011c). The assessment of situational interest can be used to compare classrooms in which the hook is used at the beginning of class and in the middle. That is, the exploratory and preparatory pedagogical approaches could be compared in a quantitative manner. Furthermore, expanded qualitative studies could take place at an international level using the design set out in the current thesis. Additionally, a further qualitative study could be used to assess the differences between the hook and para-hook impact models and pedagogical approaches.

Other work needs to be conducted by varying the style of hook. The current thesis attempted to optimise the hook design, however, new types of hook could be developed by varying design sensitivities to broaden the diversity of approaches. The implementation of such designs would provide a comparator to assess the minutia of detail involved in instructional design. Furthermore, hooks could be developed for other subject areas. This represents a moderate leap for chemistry and biology, but a considerable one for other subject areas like languages. In concert, comparisons can be made within contexts, more international settings may prove to have differing results. Moreover, different age groups may react differently to the hooks. Primary school, older secondary school and third level students have not been assessed in any capacity. Hooks in these settings may prove to be vital in improving pedagogical practice along with the student experience.

Indeed, at the core of the current research is the student experience. Science is a fundamental subject that permeates every facet of life. As a science teacher, the researcher's aim for the research was to advance science education on the ground, in the classroom. The thesis has

Chapter 9: Findings and Conclusions

brought design research to the fore in science education and illuminated interest and engagement development in science through collaboration with teachers and students. It is hoped that the novel hook methodology instigated will inspire more research into design, design models, technology enhanced educational environs, stakeholder opinions and worldviews along with students' affective and cognitive reactions in class, which in summation will continue to improve science and physics education in Ireland and beyond.

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Appendices

Appendix A: Links to the Physics Video Hooks

http://www.sciencehooks.scoilnet.ie/?page_id=75

<http://tinyurl.com/physicshooks>

Appendix B: Participant Recruitment

Email to the 2014 cohort of students enrolled in the Professional Masters in Education (PME) (2014) for design cycle 1 (pilot).

Hi all,

I am sure you enjoyed the ecology fieldtrip. I am sending an email to remind you about my PhD pilot study using physics hooks. My research is trying to develop a best practice methodology for their use in class so anyone who is interested in getting involved in this it would be greatly appreciated. The pilot will involve incorporating one of the physics video hooks into one of your lessons with a Junior science class. You will be asked to use the hook at the beginning of the lesson, but the topic of the video must match the topic being taught in the lesson. I will visit your school and record the lesson and then conduct an informal interview afterwards about the class and pedagogy. Please note that your participation in this study can be used as a topic for your inquiry based teaching activity (portfolio part 5). In return for your participation, you will receive leaving certificate Agricultural science exam notes and Junior science resources. More importantly, however, you will be part of a project that aims to improve science education.

I am looking for students to contact me as soon as you can so a meeting can be arranged.

My email is: m.mchugh2@nuigalway.ie

Thanks again,

Martin McHugh

Recruitment flyer used in design cycle 2.

The flyer features a blue header with a dashed white border. On the left is a portrait of Martin McHugh in a red hoodie. To the right, the text 'Hello Science Teacher!' is written in a large, black, monospace font. Below this, a paragraph of text is enclosed in a dashed white box. A blue decorative shape is on the right side of the header. Below the header, the text 'This is how it works:' is centered and underlined with a blue dashed line. Three steps are listed, each in a colored box: Step 1 (red border), Step 2 (grey border), and Step 3 (yellow border). At the bottom, there is a central text block, contact information with icons for email and phone, and a footer with a blue bar containing funding information and the NUI Galway logo. Dotted blue lines are scattered on the right side of the page.

Hello Science Teacher!

My name is Martin McHugh and I am a former science teacher and now a doctoral researcher at NUI Galway. I am inviting you to participate in a research study about science teachers' use of video resources and the impact this has on their students' learning.

This is how it works:

Step 1:

The study will provide you with a set of Junior Science **Physics videos**, called 'video hooks'. A 'hook' is a teaching aid designed to be interesting, engaging and attention grabbing to students and I want to investigate how well they work. Hook examples can be found online at:
<http://www.sciencehooks.scoilnet.ie/physics/atmospheric-pressure/>

Step 2:

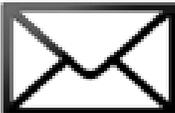
Those who partake in this study will identify one junior science class and implement 3 physics hooks into their teaching. I will **observe** the third lesson.

Step 3:

After the observation, there will be an **interview** to share your views on the process and make a positive impact on JC physics. Working on the project will form part of your professional development and benefit your school science department!

The project will work with *ten* teachers. All teachers will be entered into a draw to win a **Celestron Astromaster Telescope!**

Please contact me if you like to be part of this exciting project starting January 2015

 m.mchugh2@nuigalway.ie  (086) 158 1200

This project is funded by the NUI Galway Hardiman Scholarship

 OÉ Gaillimh
NUI Galway

Informed Consent Form

Dear Teacher,

Date:

This informed consent form is for Junior Science secondary teachers who are invited to participate in the research titled “Video Hooks in the Junior Physics Classroom”.

Research project: Video Hooks in the Junior Physics Classroom

Main researchers: Martin McHugh and Dr Veronica McCauley

Organisation: School of Education, National University of Ireland, Galway (NUI Galway)

This Informed Consent Form has two parts:

- **Information Sheet (to share information about the study with you)**
- **Certificate of Consent (for signatures if you choose to participate)**

Information sheet

Introduction

My name is Martin McHugh and I am a doctoral student at NUI Galway. I am a former science teacher in St. Louis Community School Kiltimagh, Co. Mayo and Yeats College, Co. Galway. I am currently undertaking research on how Junior Science teachers use video ‘hooks’ in their teaching. A ‘hook’ is a teaching aid designed to be interesting and engaging to students. With your participation, I hope to explore how teachers use the resource in a real classroom scenario. The specific videos that are being used in this study can be found online at <http://www.sciencehooks.scoilnet.ie/physics/atmospheric-pressure/>. With this, you will be given support material that connects the videos to the syllabus and explains background science. The overall aim of this project is to improve science teaching and the student experience of Junior Science.

Procedure

If you agree to participate in this research, we would provide you with a complete set of video hooks to supplement your current resources. We would then ask you incorporate one of these videos into a relevant science lesson. We would also ask you to contribute to our research by giving us permission to observe this lesson. The primary researcher (Martin McHugh) will observe at the back of the classroom. In addition, we would like to conduct one interview after the completion of the project. The interview will take between 30 and 40 minutes and will be audio recorded and transcribed at a later date. Interview questions will be about teaching with the video hooks. Teachers will be given transcriptions to review and adjust.

The project will commence in January 2015.

Confidentially

We would like to assure you that your contributions will be treated with the strictest confidence. Names, names of other people, schools, places or any information that may disclose a participants/school identity will be anonymized before data analysis takes place. When presenting

results, we will take special care to assure that no conclusions can be drawn as to the identities of any participants and/or schools.

If you have any concerns about this study and wish to get in touch with someone independent and in confidence, you may contact: The Chairperson of the NUI Galway Research Ethics Committee, C/o Office of the Vice President for Research, NUI Galway Tel 091 524411 (extension 5312) 091 495312 (direct) Email ethics@nuigalway.ie

Certificate of Consent

This form is part of a process of informed consent. You should have an idea of what the research is about and what your contribution will involve. If you would like more detail about the project, feel free to contact me at the following:

Email: m.mchugh2@nuigalway.ie

Phone: 0861581200

Address: Second Floor, Hardiman Building, National University of Ireland Galway, University Road. Galway.

Supervisor: Dr Veronica McCauley – veronica.mccauley@nuigalway.ie

I _____ (teachers name) give researchers in the School of Education in NUI Galway permission to perform one interview, which will be audiotaped. I also give permission for the observation of one of my lessons by the primary researcher (Martin McHugh). I understand that all contributions will be treated with the strictest confidence. I also understand that only the two researchers (Martin McHugh, Dr Veronica McCauley) will have access to observation and audio data. Any results from this study may be presented orally at lectures and conferences and in academic publications.

Participants Signature:

I have read and understood the description of the research project provided. I have had ample time and opportunity to ask questions or make inquiries about the project. I understand that I may withdraw my consent to contribute to this research at any time by contacting the primary researcher: Martin McHugh

Print Name of Participant _____

Signature of Participant _____

Date _____

Informed Consent Form

Dear Parent/Guardian,

Date:

This informed consent form is for Parents/Guardians of students in (School name) who are invited to participate in the research titled “Video hooks in the Junior Physics Classroom”.

Research project: Video Hooks in the Junior Physics Classroom

Main researchers: Martin McHugh and Dr Veronica McCauley

Organisation: School of Education, National University of Ireland, Galway (NUI Galway)

Information sheet

Introduction

My name is Martin McHugh and I am a doctoral student at NUI Galway. I am a former science teacher in St. Louis Community School Kiltimagh, Co. Mayo and Yeats College, Co. Galway. I am currently undertaking research on how Junior Science teachers use video ‘hooks’ in their teaching. A ‘hook’ is a teaching aid designed to engage students in learning. The overall aim of this project is to improve science teaching and the student experience of Junior Science using the video hooks. To do this, we will be interviewing Junior Science teachers and observing one lesson in which the video hook is used. We would invite you to contribute to our research by providing permission for your child to be observed within the classroom setting. This work is being conducted with the full co-operation of (Name of school) and teaching staff.

The research will take place in January 2015.

The specific videos that are being used in this study can be found online at <http://www.sciencehooks.scoilnet.ie/physics/atmospheric-pressure/>

Confidentially

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Certificate of Consent

If you would like more detail about the project, feel free to contact me at the following:

Email: m.mchugh2@nuigalway.ie

Phone: 0861581200

Address: Second Floor, Hardiman Building, National University of Ireland Galway, University Road. Galway.

Please return this signed form to (School name) by January 2015.

I _____ (Parent/Guardian name) give researchers in the School of Education in NUI Galway permission to conduct an observation of my child's class in one lesson. I understand that all contributions will be treated with the strictest confidence. I also understand that only the two researchers (Martin McHugh, Dr Veronica McCauley) will have access to notes and observations. Any results from this study may be presented orally at lectures and conferences and in academic publications.

Participants Signature:

I have read and understood the description of the research project provided. I understand that I may withdraw my consent to contribute to this research at any time by contacting the primary researcher: Martin McHugh

Print Name of Parent/Guardian _____

Signature of Parent/Guardian _____

Name of student _____

Date _____

If you have any concerns about this study and wish to get in touch with someone independent and in confidence, you may contact:

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Informed Assent Form

Dear Student,

Date:

This informed consent form is for Junior Science secondary students who are invited to participate in the research titled “Video Hooks in the Junior Physics Classroom”.

Research project: Video Hooks in the Junior Physics Classroom

Main researcher: Martin McHugh

Organisation: School of Education, National University of Ireland, Galway (NUI Galway)

Introduction

My name is Martin McHugh and I am a student at NUI Galway. I am a science teacher and have returned to study how teachers use videos in science. I am also looking at how these videos impact on students. The videos your teacher will be using are designed to be interesting and engaging to students. The aim of this project is to improve science teaching and the student experience of Junior Science. We would ask you to help with this research by allowing the primary researcher (Martin McHugh) to observe one of your lesson. The project will start in January 2015. We would like to assure you that the only person who will observe the class is the researcher. All names and information about the school will be changed. If you would like more detail about the project, feel free to ask the teacher or contact me at **Email:** m.mchugh2@nuigalway.ie

Address: School of Education, National University of Ireland Galway, University Road. Galway.

I _____ (students name) give researchers in the School of Education in NUI Galway permission to observe one lesson by the primary researcher (Martin McHugh). I understand that all contributions will be treated with the strictest confidence.

I have read and understood the description of the research. I know that I don't have to take part if I don't want to and can withdraw at any time by talking to my teacher and contacting the primary researcher - Martin McHugh

Print Name of Student _____

Signature of Student _____

Date _____

Please hand this sheet to the teacher when you are finished.

If you have any concerns about this study and wish to get in touch with someone independent and in confidence, you may contact:

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Date:

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Information sheet

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My name is Martin McHugh and I am a doctoral student at NUI Galway. I am a former science teacher in St. Louis Community School Kiltimagh, Co. Mayo and Yeats College, Co. Galway. I am currently undertaking research on how Junior Science teachers use video ‘hooks’ in their teaching. A ‘hook’ is a teaching aid designed to be interesting and engaging to students. With your participation, I hope to explore how teachers use the resource in a real classroom scenario. The specific videos that are being used in this study can be found online at <http://www.sciencehooks.scoilnet.ie/physics/atmospheric-pressure/>. With this, you will be given support material that connects the videos to the syllabus and explains background science. The overall aim of this project is to improve science teaching and the student experience of Junior Science.

Procedure

If you agree to participate in this research, we would provide you with a complete set of video hooks to supplement your current resources. We would then ask you to choose three of these videos and incorporate each one into a science lesson within ideally a two/three-month period. We would also ask you to contribute to our research by giving us permission to observe the third and final lesson in which the hook is used. The primary researcher (Martin McHugh) will observe at the back of the classroom. In addition, we would like to conduct one interview after the completion of the project. The interview will take between 30 and 40 minutes and will be audio recorded and transcribed at a later date. Interview questions will be about teaching with the video hooks. Teachers will be given transcriptions to review and adjust.

The project will commence in January 2015.

Confidentially

We would like to assure you that your contributions will be treated with the strictest confidence. Names, names of other people, schools, places or any information that may disclose a

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Phone: 0861581200

Address: Second Floor, Hardiman Building, National University of Ireland Galway, University Road. Galway.

Supervisor: Dr Veronica McCauley – veronica.mccauley@nuigalway.ie

I _____ (teachers name) give researchers in the School of Education in NUI Galway permission to perform one interview, which will be audiotaped. I also give permission for the observation of one of my lessons by the primary researcher (Martin McHugh). I understand that all contributions will be treated with the strictest confidence. I also understand that only the two researchers (Martin McHugh, Dr Veronica McCauley) will have access to observation and audio data. Any results from this study may be presented orally at lectures and conferences and in academic publications.

Participants Signature:

I have read and understood the description of the research project provided. I have had ample time and opportunity to ask questions or make inquiries about the project. I understand that I may withdraw my consent to contribute to this research at any time by contacting the primary researcher: Martin McHugh

Print Name of Participant _____

Signature of Participant _____

Date _____

Informed Consent Form

Dear Parent/Guardian,

Date:

This informed consent form is for Parents/Guardians of students in (School name) who are invited to participate in the research titled “Video hooks in the Junior Physics Classroom”.

Research project: Video Hooks in the Junior Physics Classroom

Main researchers: Martin McHugh and Dr Veronica McCauley

Organisation: School of Education, National University of Ireland, Galway (NUI Galway)

Information sheet

Introduction

My name is Martin McHugh and I am a doctoral student at NUI Galway. I am a former science teacher in St. Louis Community School Kiltimagh, Co. Mayo and Yeats College, Co. Galway. I am currently undertaking research on how Junior Science teachers use video ‘hooks’ in their teaching. A ‘hook’ is a teaching aid designed to engage students in learning. The overall aim of this project is to improve science teaching and the student experience of Junior Science using the video hooks. To do this, we will be interviewing Junior Science teachers and observing one lesson in which the video hook is used. We would invite you to contribute to our research by providing permission for your child to be observed within the classroom setting. This work is being conducted with the full co-operation of (Name of school) and teaching staff.

The research will take place in January 2015.

The specific videos that are being used in this study can be found online at <http://www.sciencehooks.scoilnet.ie/physics/atmospheric-pressure/>

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If you would like more detail about the project, feel free to contact me at the following:

Email: m.mchugh2@nuigalway.ie

Phone: 0861581200

Address: Second Floor, Hardiman Building, National University of Ireland Galway, University Road. Galway.

Please return this signed form to (School name) by January 2015.

I _____ (Parent/Guardian name) give researchers in the School of Education in NUI Galway permission to conduct an observation of my child's class in one lesson. I understand that all contributions will be treated with the strictest confidence. I also understand that only the two researchers (Martin McHugh, Dr Veronica McCauley) will have access to notes and observations. Any results from this study may be presented orally at lectures and conferences and in academic publications.

Participants Signature:

I have read and understood the description of the research project provided. I understand that I may withdraw my consent to contribute to this research at any time by contacting the primary researcher: Martin McHugh

Print Name of Parent/Guardian _____

Signature of Parent/Guardian _____

Name of student _____

Date _____

If you have any concerns about this study and wish to get in touch with someone independent and in confidence, you may contact:

The Chairperson of the NUI Galway Research Ethics Committee, C/o Office of the Vice President for Research, NUI Galway Tel 091 524411 (extension 5312) 091 495312 (direct) Email ethics@nuigalway.ie

Informed Assent Form

Dear Student,

Date:

This informed consent form is for Junior Science secondary students who are invited to participate in the research titled “Video Hooks in the Junior Physics Classroom”.

Research project: Video Hooks in the Junior Physics Classroom

Main researcher: Martin McHugh

Organisation: School of Education, National University of Ireland, Galway (NUI Galway)

Introduction

My name is Martin McHugh and I am a student at NUI Galway. I am a science teacher and have returned to study how teachers use videos in science. I am also looking at how these videos impact on students. The videos your teacher will be using are designed to be interesting and engaging to students. The aim of this project is to improve science teaching and the student experience of Junior Science. We would ask you to help with this research by allowing the primary researcher (Martin McHugh) to observe one of your lesson. The project will start in January 2015. We would like to assure you that the only person who will observe the class is the researcher. All names and information about the school will be changed. If you would like more detail about the project, feel free to ask the teacher or contact me at **Email:** m.mchugh2@nuigalway.ie

Address: School of Education, National University of Ireland Galway, University Road. Galway.

I _____ (students name) give researchers in the School of Education in NUI Galway permission to observe one lesson by the primary researcher (Martin McHugh). I understand that all contributions will be treated with the strictest confidence.

I have read and understood the description of the research. I know that I don't have to take part if I don't want to and can withdraw at any time by talking to my teacher and contacting the primary researcher - Martin McHugh

Print Name of Student _____

Signature of Student _____

Date _____

Please hand this sheet to the teacher when you are finished.

If you have any concerns about this study and wish to get in touch with someone independent and in confidence, you may contact:

*The Chairperson of the NUI Galway Research Ethics Committee, C/o Office of the Vice President for Research, NUI Galway Tel 091 524411 (extension 5312) 091 495312 (direct)
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Informed Consent Form

Dear Teacher,

Date:

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Research project: Video Hooks in the Junior Physics Classroom

Main researchers: Martin McHugh and Dr Veronica McCauley

Organisation: School of Education, National University of Ireland, Galway (NUI Galway)

This Informed Consent Form has two parts:

- **Information Sheet (to share information about the study with you)**
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Information sheet

Introduction

My name is Martin McHugh and I am a doctoral student at NUI Galway. I am a former science teacher in St. Louis Community School Kiltimagh, Co. Mayo and Yeats College, Co. Galway. I am currently undertaking research on how Junior Science teachers use video ‘hooks’ in their teaching. A ‘hook’ is a teaching aid designed to be interesting and engaging to students. With your participation, I hope to explore how teachers use the resource in a real classroom scenario. The specific videos that are being used in this study can be found online at <http://www.sciencehooks.scoilnet.ie/physics/atmospheric-pressure/> . With this, you will be given support material that connects the videos to the syllabus and explains background science. The overall aim of this project is to improve science teaching and the student experience of Junior Science.

Procedure

As a teacher who has participated in this project previously, you are again invited to consider further participation in this next phase which will focus more so on your students. If you agree to participate in this research, we would provide you with a complete set of video hooks to supplement your current resources. We would then ask you to choose three of these videos and incorporate each one into a science lesson within ideally a two-month period. We would also ask you to contribute to our research by giving a two question survey to students to fill out during the last five minutes of every lesson in which the hook is used. Also, from your group of students, I would ask to recruit four of them at random to participate in a 30-minute group interview during class time. The group interview will ascertain student opinions about the hooks and the schedule/questions are available to teachers and students before the interview. In addition, we would like teachers to write a simple summary/description on the three lessons in which the hook is used.

The project will commence in October 2015.

Confidentially

We would like to assure you that your contributions will be treated with the strictest confidence. Names, names of other people, schools, places or any information that may disclose a

participants/school identity will be anonymised before data analysis takes place. When presenting results, we will take special care to assure that no conclusions can be drawn as to the identities of any participants and/or schools.

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Email ethics@nuigalway.ie**



Consent Form

Title of Study: Video Hooks in the Junior Physics Classroom.

Name of Researcher: Martin McHugh - m.mchugh2@nuigalway.ie

Please tick box

1: I confirm that I have read the above information sheet and have had the opportunity to ask questions.

2: I am satisfied that I understand the information provided and have had enough time to consider the information provided.

3: I understand that my participation is voluntary and that I am free to withdraw at any time, without any reason and without my legal rights being affected.

4: I understand that all contributions will be treated with the strictest confidence. Any results from this study may be presented orally at lectures and conferences and in academic publications.

Name of Participant	Date	Signature

Researcher	Date	Signature

If you have any concerns about this study and wish to get in touch with someone independent and in confidence, you may contact:
The Chairperson of the NUI Galway Research Ethics Committee, C/o Office of the Vice President for Research, NUI Galway Tel 091 524411 (extension 5312) 091 495312 (direct)
Email ethics@nuigalway.ie

Informed Consent Form

Dear Parent/Guardian,

Date:

This informed consent form is for Parents/Guardians of students in (School name) who are invited to participate in the research titled “Video hooks in the Junior Physics Classroom”.

Research project: Video Hooks in the Junior Physics Classroom

Main researchers: Martin McHugh and Dr Veronica McCauley

Organisation: School of Education, National University of Ireland, Galway (NUI Galway)

Information sheet

Introduction

My name is Martin McHugh and I am a doctoral student at NUI Galway. I am a former science teacher in St. Louis Community School Kiltimagh, Co. Mayo and Yeats College, Co. Galway. I am currently undertaking research on how Junior Science teachers use video ‘hooks’ in their teaching. A ‘hook’ is a teaching aid designed to engage students in learning. The overall aim of this project is to improve science teaching and the student experience of Junior Science using the video hooks.

To do this, we will be working with Mr/Ms. (Science teacher) who has agreed to work on the project. We would invite you to contribute to our research by providing permission for your child to fill out a brief survey on three of their lessons that will be taught using a short physics video. In addition, your child may be asked to take part in a group interview of four students where they will be asked to give their opinion on the videos. The group interview will take 30 minutes and be audio recorded. This will take place during school time. Mr/Ms (Science teacher) has agreed to support the interview and ensure that students will catch up with lesson content. The primary researcher (Martin McHugh) will conduct the group interview. This work is being conducted with the full co-operation of (Name of school) and teaching staff.

The research will take place in December 2015.

The specific videos that are being used in this study can be found online at <http://www.sciencehooks.scoilnet.ie/physics/atmospheric-pressure/>

Confidentially

We would like to assure you that contributions will be treated with the strictest confidence. Names of people, schools, places or any information that may disclose a participants/school identity will be anonymised before data analysis takes place. When presenting results, we will take special care to assure that no conclusions can be drawn as to the identities of any participants and/or schools.

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Informed Assent Form

Dear Student,

Date:

This informed assent form is for Junior Science secondary students who are invited to participate in the research titled “Video Hooks in the Junior Physics Classroom”.

Research project: Video Hooks in the Junior Physics Classroom

Main researcher: Martin McHugh

Organisation: School of Education, National University of Ireland, Galway (NUI Galway)

Information sheet

My name is Martin McHugh and I am a researcher at NUI Galway. I am a science teacher and I’m involved in a research study about how teachers use videos in science. I am also looking at how these videos affect students. Your input would be greatly valued! The select videos (which we call ‘video hooks’) your teacher will be using are designed to be interesting and engaging to students. The aim of this project is to improve science teaching and the student experience of Junior Science. I am asking you to help with this research by filling out a small survey (two questions) at the end of every class where a video is used (three classes in total). I also hope that four students from your class will agree to take part in a group interview with myself (teacher researcher) to give your opinion on the videos. The interview will be audio recorded.

The project will start in October 2015.

All names and information about the school will be changed.

If you would like more detail about the project feel free to ask the teacher or contact me at

Email: m.mchugh2@nuigalway.ie

Address: School of Education, National University of Ireland Galway, University Road. Galway.



Student Assent Form

Please hand this sheet to the teacher when you are finished.

Title of Study: Video Hooks in the Junior Physics Classroom.

Name of Researcher: Martin McHugh

Please tick box

1: I confirm that I have read and understand the above information sheet and have had the opportunity to ask questions

2: I am satisfied that I understand the information provided and have had enough time to consider the information provided.

3: I understand that my assent is voluntary and that I am free to withdraw at any time, without any reason and without my legal rights being affected.

4: I understand that all contributions will be treated with the strictest confidence. Any results from this study may be presented orally at lectures and conferences and in academic publications.

Name of Student

Date

Signature

If you have any concerns about this study and wish to get in touch with someone independent and in confidence, you may contact: The Chairperson of the NUI Galway Research Ethics Committee, C/o Office of the Vice President for Research, NUI Galway Tel 091 524411 (extension 5312) 091 495312 (direct) Email ethics@nuigalway.ie

Appendix C: Research Tools

Design Cycle 1 Interview Schedule

General/Teaching strategy

1. What are your thoughts on video hooks and the project as a whole?
2. Describe the impact, if any, that video hooks had on your teaching?
3. What teaching strategies did you use in association with the video hooks?
4. The literature suggests it is best to use a hook during the lesson introduction, how did you find this?
5. Under perfect conditions, what do you think is the best way to teach with video hooks?

Application

6. Would you have preferred to perform a live demo of the video hook content? Y/N, Why?
7. Does the hook need to be relevant to the specific topic being taught in the class? For example, if you are teaching about the centre of gravity, does the hook have to be about the centre of gravity or could it be about anything?
8. How often would you use a video hook?

Student

9. Describe the impact, if any, that the video hooks had on your students?
10. The video hooks are designed to have an influence on attention. Did you notice this influence over the course of the study?
11. The video hooks are designed to have an influence on interest. Did you notice this influence over the course of the study?
12. The video hooks are designed to be engaging. Did you notice this among students over the course of the study?
13. How long did the impact of a video hook last?

Time

14. Do you think video hooks would work as a long term method of developing sustained attention, interest or engagement in science? Y/N, Why?

Design

15. How would you improve the video hooks?

16. What are the pros and cons of these video hooks?

17. Are there advantages or disadvantages to using video as a hook medium? Some hooks may use video games or live demonstrations. What is your stance?

Biographical Information

Name:

Sex:

Years of teaching experience:

Subjects taught:

Class:

School:

Design Cycle 2 – Interview Schedule

Hook project interview questions

General/Teaching strategy

1. What are your thoughts on the hooks project as a whole? (*Do they work, worthy resource?*)
2. Describe the impact that the video hooks had on your teaching, if any?
3. Can you describe the teaching strategy that you employed in association with the hook? (*Why did you use this strategy?*) (*Has this strategy changed over the course of the project?*)
4. Do you think the teaching environment that you have in your class impacts on the hook?

Video

5. What process do you go through when deciding on what videos to use in class?
6. How do you decide on how to use the video in class?
7. Do you use them as hooks or for other applications?
8. Do you need to make a distinction between a video hook and a video? Is there a need for specifically designed video hooks?

Application

9. Would you have preferred to perform a live demo of the video hook content?

Student

10. Describe the impact, if any, that the video hooks had on your students?
11. Were there any differences in the way hooks impacted on stronger vs weaker students?
12. The video hooks are designed to have an influence on attention, interest and engagement. Did you notice this influence over the course of the study or would you use another word to describe the impact?
13. How long do you think any impact lasted on the class?
14. The videos are characterised as hooks; do you think their main purpose is as a hook or do you think it could be used as a revision tool or a transition tool in class?
15. Do you think the students' level of prior knowledge influences how effective the hook will be?

Time

16. If you used the videos on a regular basis, do you think that the video hooks would work as a long-term method of developing sustained attention, interest or engagement in science or physics?

Design

17. How would you improve the video hooks?
18. What are the worst features about the video hook design?
19. What are the best features about the video hook design?
20. If you could design your own video hook, what would you make and what would you include?

Observation Schedule for design cycles 1 and 2

Observation Schedule

Notes – Reflective/Analysis

Teacher:

School:

Date:

Time of class:

Location of class:

Numbers in class:

Male:

Female:

Specific topic being taught:

Was this the introduction to the topic:

Hook used:

Time at which hook was used:

What technology was used to play the hook?

Pre-teaching method(s):

Teaching method(s) employed with hook:

Post teaching method(s) employed with hook:

Student reaction just before hook:

Student reaction during hook:

Student reaction immediately post hook:

Student reaction throughout lesson post hook:

Notes – Descriptive/Reflective (continued)

Drawing of classroom (Plan)

Spatial Organisation of the classroom (description/reflections)

Post observation full description/reflection:

Note: Notes in this section will fully delineate what happened in class in a descriptive and neutral manner. Reflections will be dispersed throughout using the letters O.C. This stands for Observers Comment. Separate paragraphs should be used for any changes in variation of events.

Research tools for design cycle 3

Student Exit Cards – Situational Interest Measure

Please fill out this survey about your lesson

1: What was the most interesting thing/part of today's science class?

2: Why?

Group Interview Schedule Guide

This is a rough guide to be followed during the focus groups with the students. Other ancillary questions may come up throughout the focus group not accounted for in the schedule.

Icebreaker – Ask the students to come up with and announce their own pseudonym

Starter – After this, the students will be asked to watch one of the hooks they have seen before in class.

Questions

1: What do you think of the video?

Prompts – Likes/Dislikes

2: What's the best thing about the video?

3: What's the worst thing about the video?

5: Does the video get your attention in class? Why?

6: Do you think the video would make you more or less interested in physics? Why?

7: Does the video make you think more about physics? Why?

8: What would you do if you could make your own physics video?

9: How would you like to your teacher to use this video in class?

Do you have any questions about the project or videos?

Science Hooks – Teacher Record

Date:

1: Which hook was used?

2: Describe the teaching methodology used in association with the hook.

3: Why did you choose this way of teaching with the hook?

4: Describe the student reaction to the hook.

Appendix D: Analysis

Sub-codes, categories and themes for design cycle 1

Sub - Code	Sou	Ref	Category	Sou	Ref	Theme	Sou	Ref
Design of hooks	0	0	Design of hooks	0	0	Design of hooks - Cognitive demand	7	10
Cross curricular links	2	3	Cross curricular links	2	3	Pedagogical requirements - Prior knowledge	8	20
Everyday relevance	3	4	Everyday relevance	3	4	Pedagogy used - Hook theory	10	10
Everyday objects	1	1	Misconception - Design	1	1	Practicality - Video	7	13
Real world application	1	2	Video quality	1	2	Student Impact - Confusion	24	36
Relevance strategy	3	7	Pedagogical requirements	1	1			
Misconception - Design	1	1	Age group - class	2	6			
Video quality	1	2	Built into lesson	2	2			
Frame rate	1	1	Experiential knowledge	1	1			
Slow motion replay	1	2	Prior knowledge	1	3			
Pedagogical requirements	1	1	Refer back	1	7			
Age group - class	2	6	Segmentation	1	1	S = Sources		
Built into lesson	2	2	Pedagogy used	0	0	Ref = References		
Experiential knowledge	1	1	Hook method	2	2			
Prior knowledge	1	3	Isolated usage	2	2			
Refer back	1	7	New topic	3	3			
Segmentation	1	1	Post hook strategy	3	3			
Pedagogy used	0	0	Practicality	1	1			
Hook method	2	2	Ease of use	2	3			
Isolated usage	2	2	Resources	2	3			
New topic	3	3	Safety issues	1	1			
Post hook strategy	3	3	'Short on time'	2	6			
Practicality	1	1	Self-efficacy	1	2			
Ease of use	2	3	Student Impact	0	0			
Resources	2	3	Attention	5	7			
Safety issues	1	1	Engagement	2	2			
'Short on time'	2	6	'Over their heads'	5	10			
Self-efficacy	1	2	Student understanding	2	5			
Student Impact	0	0	Talking during hook	1	1			
Attention	5	7	Triggered SI	4	5			
Attention spans	1	1	Visual kick	2	3			
Forget the hook (Attention)	1	1	'What was that?'	3	3			
Engagement	2	2						
Emotional Engagement	1	1						
'Over their heads'	5	10						
Student understanding	2	5						
Talking during hook	1	1						
Triggered SI	4	5						
Knowledge deficit	1	3						
Visual kick	2	3						
'What was that?'	3	3						
Social approval	2	2						

Sub-codes, categories and themes for design cycle 2

Sub - Code	S	Ref	Category	S	Ref	Theme	S	Ref
Colloquial use of language	7	9	Colloquial use of language	7	9	Pedagogy - Pre + Post	12	103
Design of hooks			Design of hooks	12	103	Design - Cross curricular links	20	113
Bad music	3	4	Deviant example	2	2	Student Impact - Knowledge deficit	26	229
Can't see faces	1	1	Differentiated learning	3	5			
Cognitive design	10	16	Experiments in class	1	1			
Cross curricular links bad	4	8	Future use of videos	6	6			
Curriculum focussed	6	8	Good classroom environment	7	17			
Design flaw	5	5	Pedagogy used	20	113			
Good narration	1	2	Personal interest	7	18			
Length of video	8	12	Practicality	4	11	S = Sources		
More hooks	7	7	Pre hook method	11	48	Ref = References		
Music good	3	4	Prior knowledge	13	21			
Open ended design	7	12	Staging video	8	8			
Pragmatic design	1	1	Student Impact	26	229			
Real world application	6	6	Students asking questions	2	2			
Relevance design	6	7	Use video where it fits	5	10			
short sweet and to the point	1	5	Video Integration	4	8			
Volume and voice improvement	1	1						
Deviant example	2	2						
Differentiated learning	3	5						
Experiments in class	1	1						
Future use of videos	6	6						
Good classroom environment	7	17						
Good discipline	1	1						
Positive learning environment	3	3						
Positive reinforcement	2	4						
Student Teacher Rapport	6	7						
Pedagogy used								
Coaxing and prompting	3	4						
Conceptual learning	4	4						
Consolidation of learning	10	20						
Driving activities	1	2						
Group work	3	4						
IBL	5	10						
Misconception strategy	1	1						
Perform the hook	7	10						
Positive reinforcement	1	2						
Post questioning strategy	1	1						
Pre + Post	9	9						
Prediction strategy	5	11						
Questions pre + post	4	4						
Segmentation	10	20						
Socratic Method	4	6						

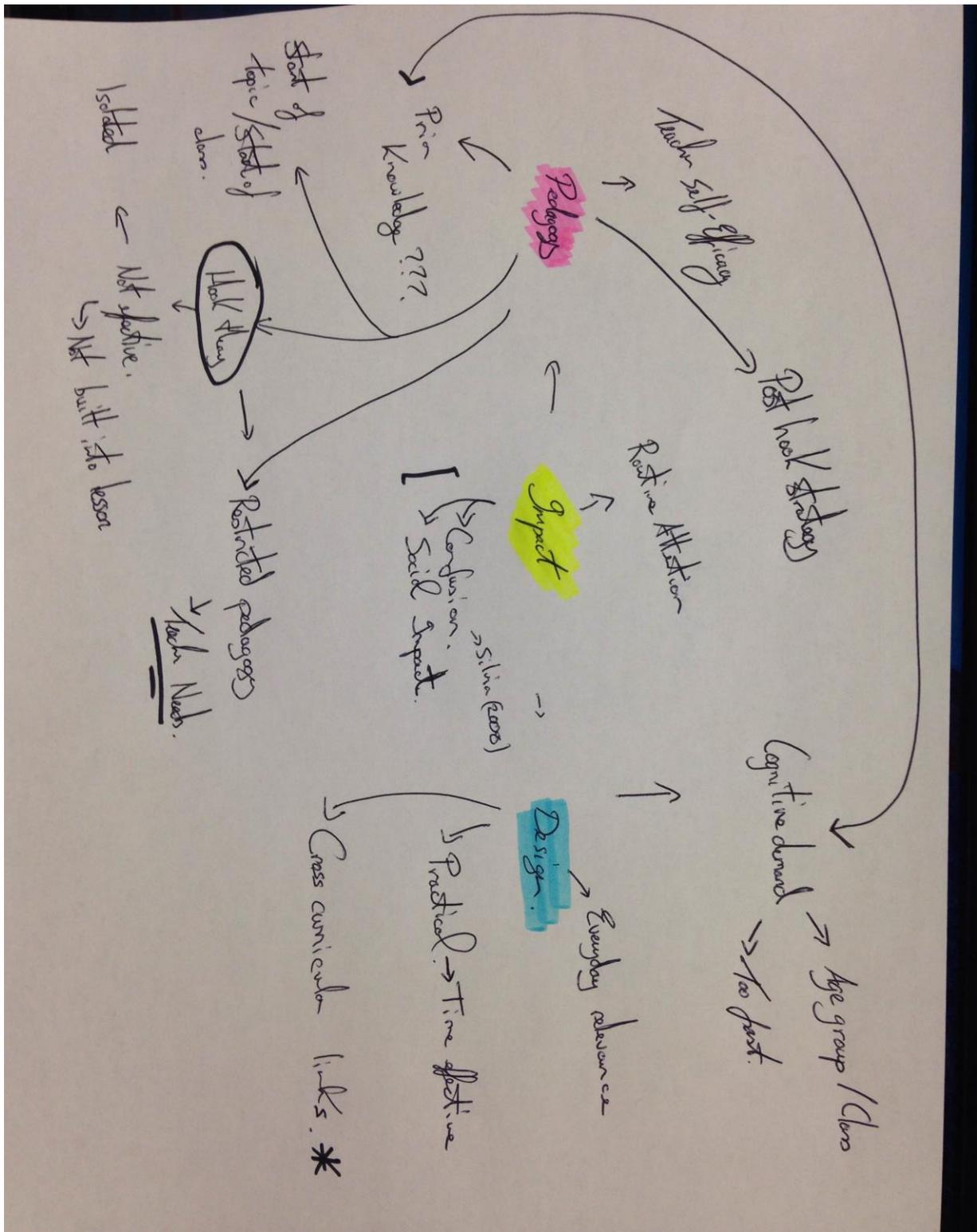
Student misconceptions	1	1							
Think pair share	4	4							
Personal interest	7	18							
Practicality	4	11							
'Fall back on'	5	9							
Time constraints	2	2							
Pre hook method	11	48							
Build up to hook	4	5							
Building concepts	9	18							
Class discussion	1	1							
Closed questions	1	1							
Demonstration	2	2							
Experiential knowledge	3	5							
Intuitive knowledge	2	4							
Open questions	3	3							
Real world application (pre hook)	5	7							
Running knowledge	1	1							
Student misconceptions	1	1							
Prior knowledge	13	21							
Running knowledge	1	2							
Staging video	8	8							
Multi-tool	6	9							
Revision lesson	6	9							
Settling tool	1	3							
Attention	19	34							
Confusion	2	4							
Disbelieving	9	17							
'Every little detail'	8	10							
Focus	5	7							
Knowledge deficit	18	48							
Knowledge gap	1	1							
Knowledge gap filled	2	2							
Meaningful SI	14	31							
Situational interest	13	23							
Social verification	4	5							
Student misconception	2	5							
Talking about video	2	2							
Thinking processes	5	13							
Triggered SI	14	28							
Students asking questions	2	2							
Use video where it fits	5	10							
Age group + class	1	3							
Behavioural issues	2	2							
Mixed ability	1	1							
Pragmatic application of video	0	0							
Video Integration	4	8							

Sub-codes, categories and themes for design cycle 3

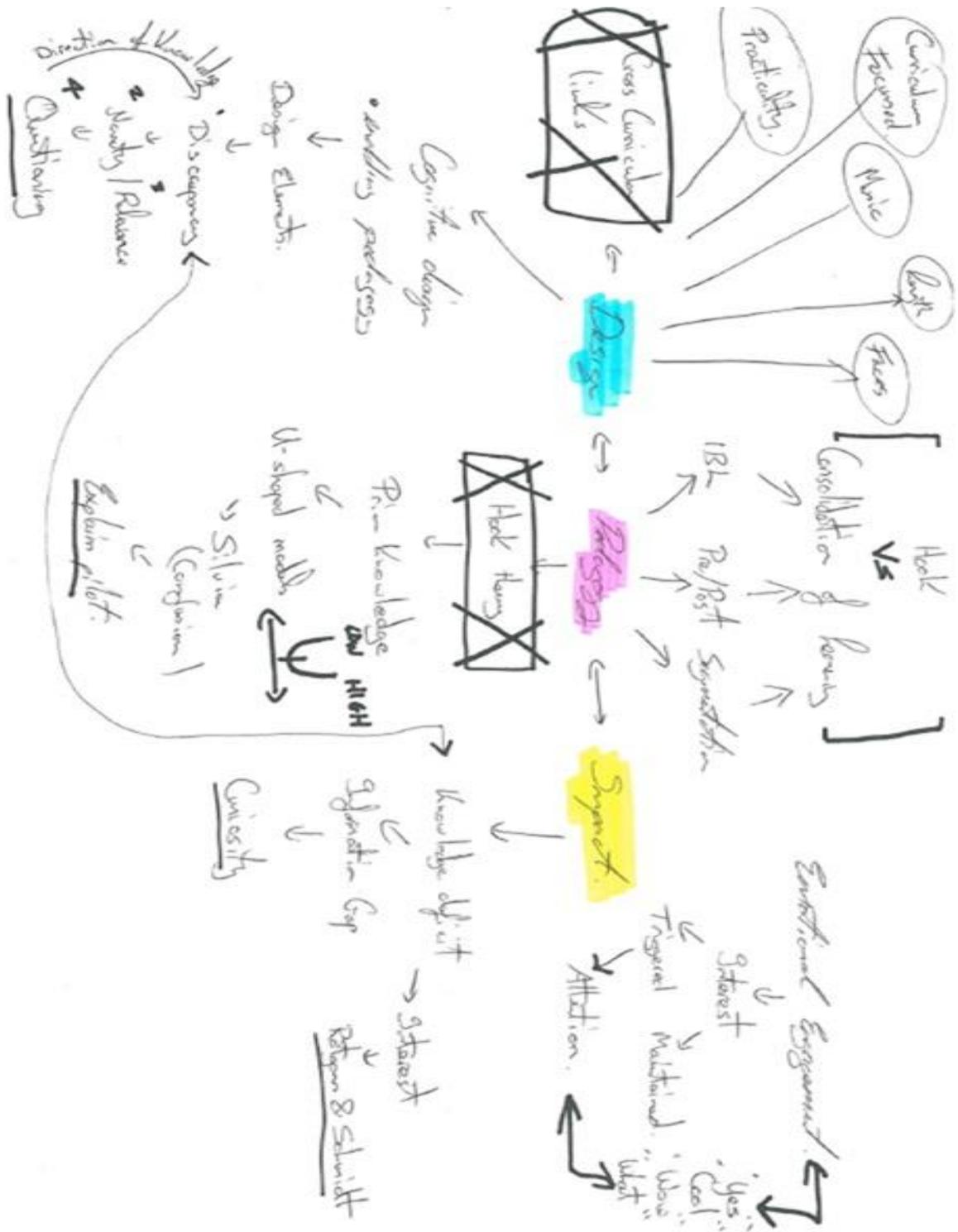
Sub - Code	S	Ref	Category	S	Ref	Theme	S	Ref
Design	0	0	Design	0	0	Design	13	23
Bad music	1	1	Bad music	1	1	Pedagogy	59	68
Curricular	2	2	Curricular	2	2	Phenomena in Video	98	101
Different angles	1	1	Different angles	1	1	Pagmatism	16	35
Explanation in hooks	6	15	Explanation in hooks	6	15	Student Impact	108	128
Good music	1	1	Good music	1	1			
Short	1	2	Short	1	2			
Wording	1	1	Wording	1	1	S = Sources		
Pedagogy	0	0	Pedagogy	0	0	Ref = References		
Coaxing and Prompting	1	1	Coaxing and Prompting	1	1			
Consolidation of learning	4	4	Consolidation of learning	4	4			
Differentiated learning	1	1	Differentiated learning	1	1			
Hook as introduction	8	10	Hook as introduction	8	10			
Hook for homework	3	4	Hook for homework	3	4			
IBL	5	7	IBL	5	7			
Independent learning	2	2	Independent learning	2	2			
Inquiry based approach	3	5	Inquiry based approach	3	5			
Integration of hook	1	1	Integration of hook	1	1			
Perform the hook	4	5	Perform the hook	4	5			
Practical Work	4	5	Practical Work	10	10			
Discrepancy in Practical	6	6	Prediction	4	4			
Process of Inquiry	4	4	Replay	2	2			
Prediction	4	4	Segmentation	4	4			
Replay	2	2	Think Pair Share	3	3			
Segmentation	4	4	Phenomena in Video	27	27			
Think Pair Share	3	3	Attention	2	2			
Phenomena in Video	27	27	Discrepancy in video	32	32			
Attention	2	2	Something I didnt know be	20	20			
Discrepancy in video	32	32	Visual Learning	17	20			
Something I didnt know b	20	20	Pragmatism	0	0			
Visual Learning	17	20	Student Pragmatism	11	30			
Pragmatism	0	0	Teacher Pragmatism	3	3			
Student Pragmatism	3	5	Student Impact	0	0			
Digital Residents	2	4	Cognitive Engagment	15	18			
Reading vs Viewing	6	21	Confidence	1	1			
Visual vs teacher talk	2	2	Confusion	30	40			
Teacher Pragmatism	2	2	Cool	17	20			
Metacognition - teacher	1	1	Deviant Case	2	2			

Student Impact	0	0	Discrepancy	6	8			
Cognitive Engagment	15	18	Hooks interesting	1	1			
Confidence	1	1	Interest in topic	1	1			
Confusion	9	14	Interest in Video Hook	19	20			
Anticipation	2	2	Maintained SI	4	4			
Emotional engagament	1	1	Meaningfulness	4	4			
Enjoyment	4	4	Memory recall	3	3			
Fostering inquiry	3	5	Personal Interest	1	1			
Intrigued	3	6	Triggered SI	3	3			
Knowledge deficit	5	5	Triggered SI over time	1	2			
Muted Reaction	1	1						
Student Misconceptions	2	2						
Cool	17	20						
Deviant case	1	1						
Custard Deviant Exampk	1	1						
Discrepancy	5	7						
Different	1	1						
Hooks interesting	1	1						
Interest in topic	1	1						
Interest in Video Hook	19	20						
Maintained SI	4	4						
Meaningfulness	4	4						
Memory recall	3	3						
Personal Interest	1	1						
Triggered SI	3	3						
Triggered SI over time	1	2						

Hand drawn thematic map for design cycle 1



Hand drawn thematic map for design cycle 2



Hand drawn thematic map for design cycle 3

