

Technology-Enhanced Inquiry-Based Learning and the Development of Higher-Order Thinking Skills in Geography in a Post-Primary School Setting

Craig Rankin B.A. (Mod.) (Dubl.), PGDE (Hons) NUI

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degree of MSc in Technology and Learning

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Declaration

I declare that the work described in this document is, except where otherwise stated, entirely my own work and has not been submitted as an exercise for a degree at this or any other university.

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MSc Technology and Learning class of 2016

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Abstract

Higher-order thinking skills such as analysis, evaluation and creative thinking are vitally important within the discipline of geography. This is because these skills allow geographers to engage with many complex real-world phenomena and issues. These issues include many pressing global concerns such as the future of energy, sustainability, development and the environment. It is by developing higher-order thinking skills that students of geography can engage with geographical issues and begin not only to understand them, but to evaluate and respond to them appropriately.

However, within an exam-focused education system, geography runs the risk of becoming a subject which is viewed as a range of topics about the planet and its people that need to be 'learnt-off' rather than a set of patterns to be explored or issues to be solved. This research is motivated by a concern that students of geography at post-primary level are not always given sufficient opportunities to develop higher-order thinking skills. This project explores how students' higher-order thinking skills might be developed through geography at post-primary school level. This research employs an exploratory mixed-methods case study to investigate how the use of technology-enhanced, inquiry-based learning approach may affect the development of higher-order thinking skills.

The results of this research show that an inquiry-based learning approach is a highly effective means of giving students the opportunity to practice and develop their higher-order thinking skills. It is concluded that technology (especially online geospatial technology) is the key to allowing for the implementation of inquiry-based learning in geography as it allows for access to a great variety of real-world authentic data, as well as a great degree of freedom for the learner. Therefore, this technology, while not the focus of the learning itself is the tool necessary to enable effective inquiry-based learning in geography.

Table of Contents

Declaration	ii
Permission to lend and/or copy	iii
Acknowledgements	iv
Abstract	v
Table of Contents	vi
List of Figures	viii
List of Tables	ix
Chapter 1: Introduction	1
1.1 <i>Why Geography Matters</i>	1
1.2 <i>Motivation for this Research</i>	2
1.3 <i>Research Aims and Questions</i>	3
Chapter 2: Literature Review	4
2.1 <i>Introduction</i>	4
2.2 <i>Key Skills and Abilities in Geography</i>	4
2.3 <i>Bloom's Taxonomy of Educational Objectives</i>	6
2.4 <i>Affordances of Technology in Geographical Education</i>	9
2.5 <i>Inquiry-based Learning (IBL) in Geography</i>	13
2.6 <i>Summary and Conclusion</i>	15
Chapter 3: Design	17
3.1 <i>Introduction</i>	17
3.2 <i>Description of the Learning Experience</i>	18
3.3 <i>Data Collection during the Learning Experience</i>	27
3.4 <i>Participants and Ethical Considerations</i>	27
3.5 <i>Conclusion</i>	28
Chapter 4: Research Methodology	29
4.1 <i>Introduction</i>	29
4.2 <i>Research Questions</i>	29
4.3 <i>Research Approach</i>	29
4.4 <i>Generalisability of the Research</i>	30
4.5 <i>Reliability and Validity of the Research</i>	31
4.6 <i>Quantitative Data Collection and Analysis</i>	31

4.7 Qualitative Data Collection and Analysis.....	34
4.8 Summary and Conclusion	38
Chapter 5: Findings & Analysis.....	40
5.1 Introduction.....	40
5.2 MTAS/ GTAS Results and Analysis	40
5.3 Design-a-City Results and Analysis	42
5.4 Questionnaire Results and Analysis.....	50
5.5 Participant Feedback on the Experience.....	57
5.6 Summary and Conclusion	61
Chapter 6: Discussion and Conclusions	63
6.1 Introduction.....	63
6.2 Addressing the Research Questions.....	63
6.3 Limitations of the Research	69
6.4 Recommendations for Future Research	71
Bibliography	72
Appendices	77
Appendix 1 – Questionnaire and Adapted MTAS (GTAS).....	77
Appendix 2 – Ethical Application and Approval.....	88
Appendix 3 – Adaptive Comparative Judgement Marking Information	98
Appendix 4 – Example of Open Coding.....	99
Appendix 5 – Open Coding Frequencies	100

List of Figures

- Figure 2.1* Golledge's scheme of spatial concepts (Jo & Bednarz, 2009)
- Figure 2.2* Comparison of original and revised versions of Bloom's taxonomy (Roberts, 2013). Question foci from the Geographical Association (2016).
- Figure 2.3* Bloom's taxonomy revised by Anderson & Krathwohl (2001) showing progression from lower-order to higher-order cognitive skills (Liu et al., 2010)
- Figure 2.4:* The SAMR Model (Puentedura, 2013)
- Figure 2.5* Essential and Optional Attributes of IBL (Spronken-Smith et al., 2008)
- Figure 2.6* Essential elements of learning geography through inquiry (Roberts, 2013)
- Figure 3.1* Themes emerging from the literature review that were incorporated into the design of the learning experience.
- Figure 3.2* A sample of the land use squares used to plan a city
- Figure 3.3* Participants work in groups to design a city during the research activity
- Figure 3.4* The menu of the VFT website showing the four cities that the participants explored during the VFT.
- Figure 3.5* 3D Google Map view showing high density housing in Hong Kong
- Figure 3.6* 3D Google Map view showing low density housing in Los Angeles
- Figure 3.7* Google Street View showing a street in Hong Kong
- Figure 3.8* City comparison tool showing Hong Kong and Dublin
- Figure 3.9* Screenshot of the Paris VFT portal page
- Figure 3.10* A sample Padlet wall (Source: <http://www.sonoma.edu/>)
- Figure 3.11* An example of a concept board created during the learning experience
- Figure 4.1* Screenshot of a judging session on www.nomoremarking.com
- Figure 4.2* A streamline codes-to-theory model for qualitative inquiry (Saldaña, 2013)
- Figure 4.3* The categories used for directed coding for each level of Bloom's Taxonomy.
- Figure 5.1* Scaled scores of the first and second designs (by group)
- Figure 5.2* City Designs H1 and H2
- Figure 5.3* City Designs B1 and B2
- Figure 5.4* Sample question to test for geographical knowledge/ understanding
- Figure 5.5* The creation of a category by combining a number of codes.
- Figure 5.6* Occurrences of the five categories for each of the four questions
- Figure 5.7* Occurrences of all five categories (per 100 words) for each of the four questions
- Figure 5.8* Results of directed analysis/ coding
- Figure 5.9* Graph showing reported participant enjoyment of the overall activity
- Figure 5.10* Favourite elements of the experience as reported by participants
- Figure 5.11* Least favourite elements of the experience as reported by participants
- Figure 5.12* Word cloud of responses to the question "How was this experience different to normal geography lesson"

List of Tables

Table 5.1 Statistical analysis of the adapted MTAS survey showing the t-values and the critical t-values for each of the 5 MTAS subcategories.

Table 5.2 Results of the ACJ sorted by scaled score. Design codes that finish with a number '2' are the participants second city designs.

Table 5.3 First and second city design scores compared and tested for statistical significance

Table 5.4 Definitions of Blooms taxonomy used for coding with examples taken from participant responses.

Chapter 1: Introduction

1.1 Why Geography Matters

“The function of geography in school is to train future citizens to imagine accurately the conditions of the great world stage and so to help them think sanely about both political and social problems in the world around.” (Fairgrieve, 1926)

This statement is as relevant to the subject of geography today as it was when it was written ninety years ago. Geography is a subject that allows students to develop their understanding of the world and their place within it. Kerski (2001) states that geography is more than simply a "nice to have" subject for an already-crowded educational curriculum. This is because it allows for the development of the critical-thinking skills, technology skills, citizen skills, and life skills that are essential in dealing with the issues that face the world today.

Geography is the study of Earth’s landscapes, peoples, places and environments (Royal Geographical Society, 2016). It is a discipline that seeks to explain the world by identifying and examining connections between a diverse range of natural and human processes. As a discipline, geography sits at the meeting point of the social and the human sciences and is therefore uniquely positioned to explore issues relating to the interaction between people and the planet. These issues include many pressing global concerns such as the future of energy, sustainability, development and the environment. Kerski (2011) notes that *“Geography grapples with the key issues of our time—energy, water, biodiversity, climate, natural hazards, population, and much more.”* As a result, a geographical perspective has become vitally important in an increasingly globalised and interdependent world as we seek solutions to many complex and interconnected issues and problems.

Students study geography not only to understand that the earth is changing, but to scientifically and analytically examine the reasons for these changes (Kerski, 2011). He also states that geography students must also have the opportunity to ask the questions *“Should the earth be changing in these ways?”* and *“is there anything that I can do about it or that I should be doing about it?”*. In this way, geography encourages us to be more socially and environmentally sensitive, informed and responsible individuals (Royal Geographical Society, 2016). These are clearly essential elements of our global citizenship in the 21st Century.

1.2 Motivation for this Research

The motivation for this research stems from a concern that students of geography at post-primary level are not always given sufficient opportunities to develop higher-order thinking skills. This is of concern as spatial thinking and reasoning skills are higher-order skills that are found at the heart of the discipline of geography. These skills allow geographers to think about and answer questions relating to the '*why of where*' - the circumstances and reasons that lead to the location and operation of natural processes and/ or human impacts on the planet. It is by developing these skills that students of geography can engage with geographical issues and begin not only to understand the issues, but to evaluate and respond to them appropriately. These skills are essential not only to help students to gain a deeper understanding of geography, but to empower students to become more informed decision makers, with an ability to make a difference in a constantly changing world (Kerski, 2011). It is the development of higher-order thinking skills that is the focus of this project.

Higher-order thinking skills such as analysis, evaluation or creative thinking are vitally important for geographers when examining and devising solutions to complex issues. If students are not given the opportunity to develop these skills by engaging with geographical topics and issues, it seems likely that geography runs the risk of becoming a subject which is viewed as a range of topics about the planet and its people that need to be 'learnt-off' rather than a set of patterns to be explored or issues to be solved. This view of the subject may be somewhat encouraged by the nature of current assessment practices at junior and senior cycles in post-primary education. It might be argued that an exam, such as the Junior or Leaving Certificate, often leads to the rote learning of topics and does not do enough to recognise and reward a student's ability to use higher-order thinking skills.

This project will explore how these higher-order thinking skills might be developed within the post-primary school context through the use of a technology-enhanced learning intervention. It will seek to ascertain how the development of these skills might be achieved in an educational context which is content-heavy and exam-focussed. The researcher is also interested in exploring how short class periods (35-40 minutes) can be used to facilitate the development of these skills as it is within these timeframes that post-primary teachers operate.

1.3 Research Aims and Questions

This research aims to investigate how the use of technology and an inquiry-based learning approach may help students of geography to develop higher-order thinking skills. The following research question will be examined;

- *How can students' higher-order thinking skills be enhanced through geography in a post-primary school context?*

The research will also examine a number of sub-questions;

- *Does an inquiry-based learning approach in geography facilitate the development of higher-order thinking skills?*
- *Does the use of technology impact on student engagement with or attitudes to geography?*
- *How might the use of technology impact on the development of higher-order thinking skills?*

The research took the form of an exploratory mixed-methods case study and used both qualitative and quantitative research techniques in order to investigate various aspects of the research question and sub-questions. The participants were the researcher's transition year students, numbering 36 in total. These students were in two separate class groups. One group was undertaking a geography module on urban planning while the second group were taking a module on urbanisation as part of a Global Issues course.

Chapter 2: Literature Review

2.1 Introduction

This chapter will review the literature relevant to the design and implementation of this research. The review will begin by outlining the key skills and abilities required for higher-order thinking in geography. Following this, the affordances of technology in the geography classroom will be discussed before finishing with an examination of the literature relating to the use of inquiry-based learning in geography education.

2.2 Key Skills and Abilities in Geography

Geography is a spatial science, that is to say that it is concerned with investigating and explaining the spatial distribution of natural and human phenomena (Tuan, 1977). One of the main aims of the discipline is to “*understand spatial patterns, linkages, and relationships*” (Kerski, 2008, p.128) within real-world settings. In order to achieve this, geographers must develop a range of spatial thinking skills. However, despite its central role within the discipline, there has been little agreement as to what ‘spatial thinking’ actually is (Schultz, Kerski & Patterson, 2008).

Despite the difficulty in developing a generally accepted definition of spatial thinking, many recognise its importance. In the United States, the Geographical Sciences Committee of the National Research Council have noted that;

“...In terms of its power and pervasiveness, spatial thinking is on a par with, although not yet as well recognised and certainly not as well formulated as, mathematical or verbal thinking...” (National Academy of Sciences, 2006, p. 44)

Many observers have pointed to a recent increase in the importance of spatial thinking within many academic and professional fields over the past two to three decades (Bodzin & Cirucci, 2009; Lee & Bednarz, 2009). This is because many of the local, regional and global issues facing society today have a spatial dimension. Such issues include traffic congestion, population growth, urban sprawl, energy, water, crime, pollution, global warming and biodiversity loss

(Kerski, 2008). Thus spatial thinking has become a key competency and a requirement in 21st century society (Bednarz, Acheson & Bednarz, 2006).

In an attempt to clarify the nature of spatial thinking, the National Academy of Sciences (2006) proposes a definition that sees spatial thinking as “based on a constructive amalgam of three elements: concepts of space, tools of representation, and processes of reasoning” (p. 3). Each of these elements will now be examined;

Concepts of Space

Spatial concepts are the building blocks of spatial thinking (National Academy of Sciences, 2006). Golledge (in Jo & Bednarz, 2009) has organised such spatial concepts into a hierarchy ranging from spatial primitives, simple-spatial and complex-spatial concepts (fig. 2.1). Each level of the hierarchy represents a distinct level of abstractness and complexity (Jo & Bednarz, 2009) and thus a higher level of spatial thinking ability is required at each level. Developing an understanding of the complex-spatial concepts requires an understanding of spatial-primitive and simple-spatial concepts.

Spatial Primitives <i>Basic and fundamental characteristics of a particular place</i>	Simple-Spatial Concepts <i>Concepts established by sets of spatial primitives (e.g. Distance is the interval between locations)</i>	Complex-Spatial Concepts <i>Derived by assemblies of sets of simple-spatial concepts (e.g. a network is a set of connected locations)</i>
Place-specific identity Location Magnitude	Distance Direction Connection and Linkage Movement Transition Boundary Region Shape Arrangement Adjacency Enclosure	Distribution Pattern Dispersion and Clustering Density Diffusion Dominance Hierarchy and Network Spatial Association Overlay Layer Gradient Profile Relief Scale Map Projection Buffer

Figure 2.1 Golledge’s scheme of spatial concepts (Jo & Bednarz, 2009)

Golledge (2002) notes that these spatial concepts represent the building blocks of geographical knowledge itself. Such geographic knowledge provides a “*basis for understanding or reasoning out why there are spatial effects, not just finding what they are*” and “*to reveal patterns in spatial distributions and spatial behaviours that may not be obvious to a casual observer in the real world (e.g., the pattern of shopping centres in a city)*” (p. 6).

Tools of Representation

Maps, diagrams and graphs have long been used as tools to organise, understand and communicate spatial information and any definition of spatial thinking must acknowledge that the ability to effectively use such tools to view and create spatial representations is pivotal in developing spatial thinking (Jo & Bednarz, 2009). Recent developments in the area of geospatial technology have added to the range of tools available to represent and explore spatial data within the classroom (Kerski, 2008). This will be discussed in more detail in Section 2.4 of this literature review.

Processes of Reasoning

The core of reasoning is “going beyond” the given information (Bruner in Jo & Bednarz, 2009). Costa (in Jo & Bednarz, 2009) has identified three levels on which spatial thinking can take place. The first level (the input level) represents skills such as recognising, defining, identifying, recalling and listening. The second level (the processing level) includes abilities such as analysing, classifying and explaining. The final level (the output level) refers to the creation of new knowledge or products from previously obtained information. These three levels of spatial thinking are closely related to Bloom’s Taxonomy of Educational Objectives (Bloom, 1956; Krathwohl, 2002) and serve to highlight the importance of this taxonomy and its applicability to the discipline of Geography.

2.3 Bloom's Taxonomy of Educational Objectives

Bloom’s Taxonomy of Educational Objectives is a framework used to outline what we hope students will learn, or be able to achieve as a result of an educational intervention (Bloom, 1956). The taxonomy, which has been in widespread use in educational contexts since its publication in 1956 (Liu *et al.*, 2010), outlines definitions for each of the six major categories in the cognitive domain. These categories are knowledge, comprehension, application, analysis,

synthesis, and evaluation. They are ordered from simple to complex and from concrete to abstract, or from lower-order to higher-order (Krathwohl, 2002).

Despite its popularity and widespread use, the taxonomy was not without its critics. Ormell (1974, in Liu *et al.*, 2010) labelled the taxonomy a “*disappointingly blunt instrument*”. The reasons for this was partly due to the failure of the taxonomy to elaborate on the important distinction between the cognitive domain (relating to intellectual abilities) and the affective domain (relating to feelings and values) which are both important aspects of the learning process. As a result, the taxonomy has been revised by a number of educationalists in recent times. Arguably the most recognised revision of the taxonomy is proposed by Anderson and Krathwohl (2001). This revision aims to make the taxonomy more relevant and useful by distinguishing more clearly between the affective and cognitive domains. This revision also changed some of the terminology used to make the taxonomy more easily implemented by teachers/ instructors in educational contexts. The original nouns (e.g. knowledge, comprehension) were changed to verbs (e.g. remember, understand) and the order of the two highest order categories were reversed. These revisions can be seen in *Fig 2.2*.

Cognitive Level	Bloom (1956)	Anderson & Krathwohl (2001)	Question Foci
Highest	Evaluation	Creating	Reflect, predict, speculate, design, create, combine, hypothesise
	Synthesis	Evaluating	Assess, judge, evaluate, compare and contrast
	Analysis	Analysing	Explain, infer, draw conclusions, prioritise
	Application	Applying	Use, interpret, use in a new context, relate
	Comprehension	Understanding	Explain, summarise, describe, compare
Lowest	Knowledge	Remembering	Define, recall, describe

Figure 2.2 Comparison of original and revised versions of Bloom’s taxonomy (Roberts, 2013). Question foci from the Geographical Association (2016).

Anderson and Krathwohl's revision of the taxonomy is the version of the taxonomy that will be used in this study. It should be noted that this study is primarily concerned with the development of higher-order thinking skills and will therefore focus on the cognitive aspects of the taxonomy (see Fig 2.3). However, one of the research questions relates to attitudes and feelings towards geography and so the affective domain will be examined, but to a limited extent.

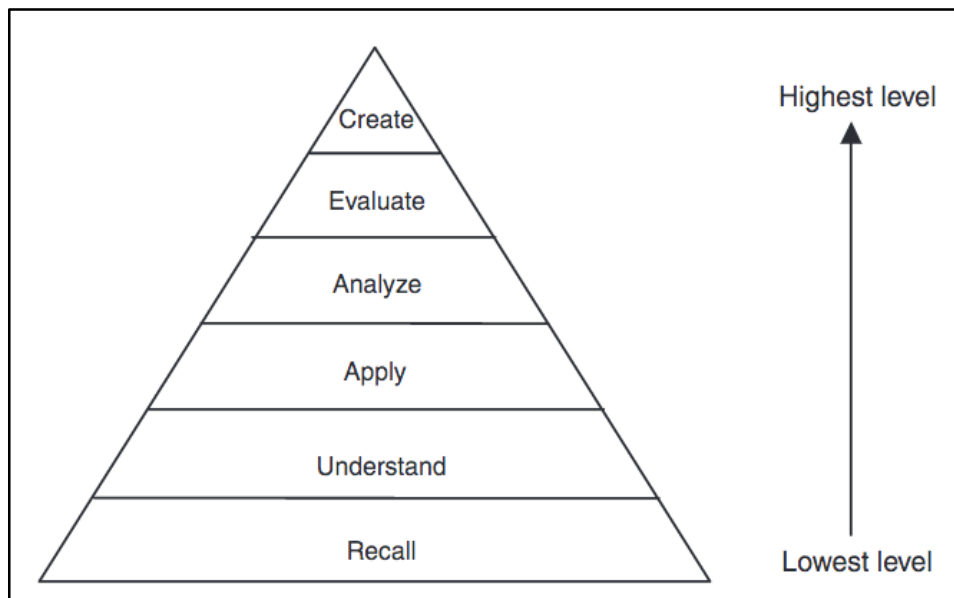


Figure 2.3 Bloom's taxonomy revised by Anderson and Krathwohl (2001) showing progression from lower-order to higher-order cognitive skills (Liu et al., 2010)

Developing higher-order thinking skills such as critical thinking, creative thinking, problem-solving and decision making is an aim clearly stated in the Leaving Certificate geography syllabus which notes that students of geography at Leaving Certificate level should be able to;

“synthesise, analyse, interpret and evaluate information (e.g. distinguish fact from opinion, draw conclusions, prove simple hypotheses, make informed judgments, suggest sensible solutions to problems and, where appropriate, suggest realistic plans for action).”
(Government of Ireland, 2003, p. 3)

2.4 Affordances of Technology in Geographical Education

“Globally connected electronic media are part of our daily lives, and twenty-first century geographical education must engage with the twenty-first century geography of people's lives. We interact with the wider world predominantly via electronic communication and information. Via the Internet, everyone can access a massive geographical database. The challenge for us as geography teachers (and a big responsibility it is) is to help our students use this communication and information in a constructive way” Chris Durbin (Forward in Martin, 2006).

It is clear that the use of technology and the internet presents many new and exciting opportunities for the teaching and learning of geography. The internet provides an endless source of geographical information that can be used to enhance the teaching of geography by bringing the world into the classroom and by allowing for the use of up-to-date real-world data. Lambert and Balderstone (2010) note that the use of technology can help students of geography to;

- enhance geographical knowledge and improve geographical inquiry skills
- develop graphical, statistical and spatial skills
- develop mapping skills
- experience alternative images of people, places and environments and how environments change
- simulate or model geographical systems and environments
- communicate with other pupils in contrasting localities by email, webcams and video conferencing
- improve the appearance of work by enhancing presentation
- increase awareness of the impact of ICT in the changing world.

While these outcomes of the use of technology are desirable and exciting, it should be noted that they are unlikely to occur as a simple or direct consequence of the use of technology *per se*. The use of technology in educational contexts should be part of a pedagogical approach that encourages active engagement with the information and tools that technology provides. It has been argued that the application of technology within the geography classroom works best within constructivist learning environments (Bodzin, Anastasio & Kulo, 2015) and that

technology and the internet should be viewed as tools to facilitate an inquiry-based learning methodology.

The power of technology to transform learning is well recognised. Puentedura's **Substitution Augmentation Modification Redefinition (SAMR)** model provides a framework for understanding the possibilities of integrating technology into the learning process (Puentedura, 2013). This model (seen in *Fig 2.4*) demonstrates that technology can be used as a **substitute** for other forms of information (for example, a digital map can be substituted for a paper map), can **augment** other tools or forms of information (such as the ability to measure distance or area on a digital map or to view a map at different scales or angles), can **modify** an educational activity (as technology provides a wealth of information and new tools that can allow for significantly redesigned educational tasks), or can **redefine** educational interventions (allowing for new forms of expression and new tasks that were previously impossible). This model highlights the fact that educational interventions can be enhanced or even transformed by the introduction of technology as new educational possibilities are made available. It is the role of the teacher/ instructor to assess how and when technology should be used in educational tasks in order to gain maximum effectiveness.

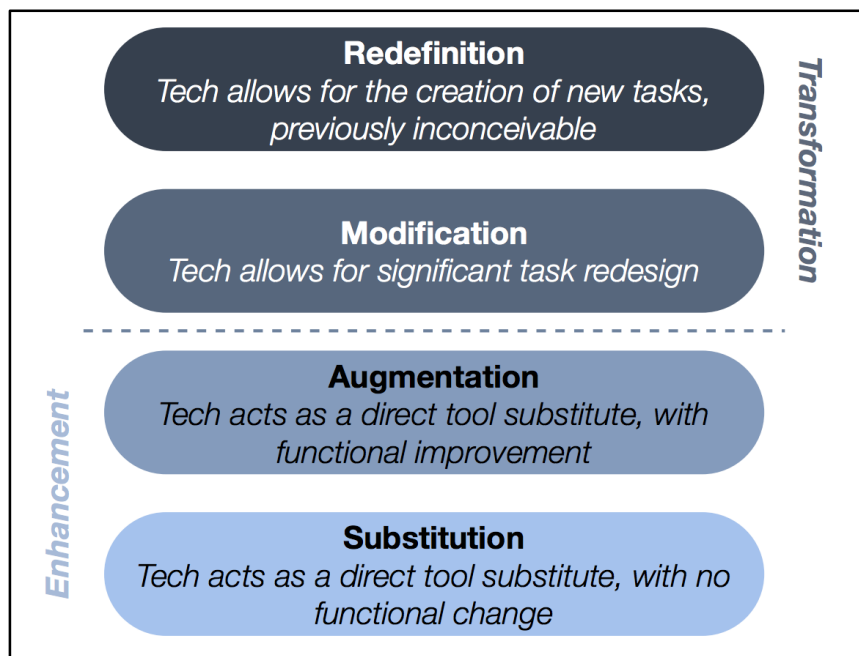


Figure 2.4: The SAMR Model (Puentedura, 2013)

One category of technology that holds particular promise in terms of enhancing or transforming geographical education is geospatial technology. Geospatial technologies include geographic information systems (GIS), global positioning systems (GPS) and remote sensing. Some believe that these technologies can be used in educational settings to improve students' spatial thinking skills and to prepare students to become the decision makers of the future (Kerski, 2008). These technologies allow for the representation, visualisation, mapping, analysis and recording of the spatial distribution of real-world processes and phenomena.

Geospatial technologies have been developing rapidly for the past 30 years (Bednarz & Van der Schee, 2006) and have certainly had a significant impact on many different professional and academic fields. Despite this, they have had a relatively small impact within educational contexts (Goldstein, 2010; Bednarz, 2004). This may be because of the high cost associated with the use of such software, its technical complexity as well as a lack of teacher training and resources. While these are all certainly relevant factors, Schultz, Kerski & Patterson (2008) note that it may be the lack of understanding of the importance of spatial thinking skills and spatial literacy that has been the key issue that has hindered the widespread adoption of geospatial technologies in the geography classroom.

Despite the slow adoption of these technologies into the classroom setting, it appears that this situation may be changing. Many of the barriers that slowed or prevented its use have been reduced or have been overcome. The development of free and low-cost, user-friendly virtual globes and maps (such as Google Earth/ Maps and Microsoft Visual Earth) has removed many of the financial, technical and logistical barriers to the implementation of geospatial technology in the classroom setting. There is also a growing awareness of the importance of spatial thinking and spatial literacy. Some believe that this change has been brought about due to a "*geospatial revolution*" in which our sense of the world is being irrevocably transformed (Downs, 2014).

It is believed that the main benefit of using geospatial technologies in the classroom is that they can allow for the development of spatial thinking and analytical skills (Demirci, 2008; Bednarz, 2004; Bodzin, Anastasio & Kulo, 2014, Bodzin & Cirucci, 2009; Burrows *et al.*, 2013). The use of this technology in the classroom also opens more possibilities for students to partake in inquiry-based learning activities (Bodzin, Anastasio & Kulo, 2014).

One relatively established means of implementing technology into the geography classroom is through the use of virtual field-trips (VFTs) (Çaliskan, 2011). A VFT can be defined as;

“a journey taken without actually making a trip to the field site... taken via an alternative means and could include slides, a movie or video, a CD-ROM, or use of the internet and Websites about a particular site... with the computer as the vehicle which moves students in virtual time and space to a particular real-world site” (Woerner in Lei, 2015, p. 323)

VFTs have been increasingly used in geoscience and geography education. It has been noted that such experiences are valuable as they allow for the augmentation, enrichment of even redefinition of the teaching and learning of theoretical concepts examined in a classroom environment (Tuthill & Klemm, 2002; Çaliskan, 2011).

Qiu & Hubble (2002) identify a number of advantages of VFTs. These advantages are of relevance within a post-primary school setting. These are that VFTs can;

- *Integrate diverse types of data in instantly available ways*
- *Present images from a variety of viewpoints and at many different scales*
- *Helpful for presenting trips to inaccessible areas*
- *Provide an alternative to fieldwork, when time, expenses, and/or logistics are real issues*
- *Enhance and expand students' experience*
- *Enable flexibility of access (time and place)*
- *Provides a repeatable experience which can be used to reinforce concepts in class*
- *Provides an easily experienced preview or review of real fieldtrips*
- *Information rich*
- *Hold abundant materials and information*
- *Offer rich resources of learning and teaching*
- *Available for users of different levels and demands*
- *Interesting and attractive to students and an alternative experience for users*

The researcher feels that these characteristics and advantages of VFTs indicate their potential to help students develop higher-order thinking skills in post-primary geography. These activities may also be a means of implementing inquiry-based learning (IBL) activities within the geography classroom.

2.5 Inquiry-based Learning (IBL) in Geography

Inquiry-based learning (IBL) is an instructional model that uses meaningful tasks such as cases, projects, and research to situate learning (Avsec & Kocijancic, 2015). It is a philosophical approach to teaching that is question-driven and involves active, student-centred learning (Spronken-Smith *et al.*, 2008). Through IBL, learners construct and process knowledge and develop reasoning skills by undertaking tasks designed to encourage an active engagement with an issue or problem. It is an approach that has been shown to be particularly effective within technology-intensive learning environments (Avsec and Kocijancic, 2015).

IBL developed in response to a shortcoming of some more traditional forms of instruction, where students are often required to memorize fact-laden content and where higher-order thinking skills such as analysis, evaluation or creative thinking are not viewed as priority outcomes. Marshall & Horton (2011) note that *“for students to excel in tomorrow’s world, they must be equipped to solve complex problems instead of just memorizing algorithms or definitions”* (p.93). Educators have become increasingly interested in IBL because of its emphasis on active, transferable learning and its potential for motivating students and improving students’ higher-order thinking skills (Avsec & Kocijancic, 2015; Marshall & Horton, 2011).

While the adoption of IBL may be relatively recent, its origins can be traced back to the work of Dewey and Vygotsky in the early and mid 20th century (Spronken-Smith *et al.*, 2008; Roberts, 2013). Dewey wrote widely on the links between thinking, reflection and experience and promoted ‘learning by doing’ or ‘active learning’ approaches (Spronken-Smith *et al.*, 2008). IBL is seen as such an approach as it places the learner at the centre of the learning process. To date, the IBL approach has been most widely adopted in disciplines such as medical training and the sciences, however the relevance of this approach to geography is increasingly recognised (Pawson *et al.*, 2006).

Despite a wealth of literature relating to inquiry-based learning, there is little consensus as to what its essential elements are. Indeed, Roberts (2013) notes that it may not be possible to give one definition of IBL which would apply in all contexts and states that *“what an inquiry approach means in practice is related to the specific contexts in which it is developed”* (p. 7). Spronken-Smith *et al.* (2008) provide a useful summary table that outlines many of the essential and optional attributes of an IBL activity (see *Fig 2.5*).

Essential Elements of IBL	Optional Elements of IBL
<ul style="list-style-type: none"> • Active approach to learning • Question-driven or research-focused • Inductive approach to teaching • Student/learner-centred with teacher as facilitator • Facilitated/ scaffolded learning • Constructivist 	<ul style="list-style-type: none"> • Collaborative/ group learning • Individual learning • University-focused • Community involvement • Field-based activity • Resource-based learning (resources provided) • Multi- or interdisciplinary focus

Figure 2.5 Essential and Optional Attributes of IBL (Spronken-Smith et al., 2008)

Inquiry has always been a cornerstone of the discipline of geography. Geographical inquiry has been often taken the form of field-work studies in which students develop geographical knowledge and thinking skills by observing and investigating a phenomenon or process first-hand. It has been argued that geography without field-work is like science without experiments and that because geography is concerned with making sense of physical and human environments and their interactions, it follows that students must have a chance to experience and interpret the world at first-hand (Lambert & Balderstone, 2010). Unfortunately, there are many logistical and financial factors that limit the number and scope of geographical field studies within formal educational settings and so alternative methods to encourage geographical thinking and inquiry skills should be sought.

Roberts (2013) notes that despite the importance of field studies to the development of students' geographical inquiry skills, an inquiry approach is as applicable in the classroom as in the field. Roberts sees IBL as a beneficial approach to teaching and learning geography in which students *"extend their geographical knowledge and understanding at the same time as they learn skills, both skills specific to geography and generic skills used in other subjects and contexts"* (p. 8). She notes that IBL approaches for teaching geography should have four key elements/ characteristics;

1. Inquiry should be question-driven

Learning geography through an IBL approach requires that a student first engages with a geographical question/ problem that needs to be answered or addressed. In this regard, it is the teacher's role to create a 'need to know'. Students need to become aware of the key questions and at the same time, these questions must become their own.

2. Inquiry should be supported by evidence

In an attempt to address the key question of a geographical inquiry, students should have the opportunity to study sources of geographical information. Roberts (2013) notes that *“In the classroom, most sources are based on secondary data, but these might be supplemented occasionally with first-hand data collected in the field, or from a questionnaire survey, or based on students’ own first-hand experiences.”* (p. 10). Students use these sources of evidence to make sense of what they are studying, support their arguments and justify their conclusions.

3. Inquiry should require geographical thinking

Roberts (2013) notes that inquiry should provide opportunities for students to *“make sense of geographical information for themselves, to make connections of all kinds”* and that *“Learning through inquiry means much more than finding answers to questions. It requires students to reason and to think critically. It means having the opportunity to reach conclusions and make judgements based on evidence.”* (p. 10).

4. Inquiry should be reflective

Throughout this process, the students should be constantly encouraged to reflect on what they have learnt and how they have come to their conclusions. It is important to note that reflection is not the end product, or the last stage of the process of IBL, but a process that takes place throughout the learning.

Roberts (2013) provides a summary of the essential elements of an IBL approach which can be seen in *Fig 2.6*.

2.6 Summary and Conclusion

Facilitating learners to develop higher-order thinking skills has become a vitally important aspect of education in the 21st century. The world is a complex and dynamic place and students must be given an opportunity to develop skills that will allow them to understand, analyse and deal with complex and unpredictable real-world issues and challenges. Geography courses at post-primary level should provide an opportunity for students to develop these skills. IBL appears to provide a suitable format within which students can engage with a real world issues and develop higher-order thinking skills in the process. The use of technology through VFT activities can allow for a greater use of IBL in the classroom.

<p>Inquiry is question-driven</p> <p>The teacher sparks curiosity, creating a need to know.</p> <p>Students:</p> <ul style="list-style-type: none"> • are curious • speculate • hypothesise • use imagination • generate ideas • identify issues • ask questions • plan how to research 	<p>Inquiry requires thinking geographically</p> <p>The teacher provides opportunities for students to make sense and exercise reasoning.</p> <p>Students:</p> <ul style="list-style-type: none"> • relate existing knowledge to new knowledge • describe • explain • compare • contrast • analyse • interpret • recognise relationships • analyse values • clarify values • reach conclusion
<p>Inquiry is supported by evidence</p> <p>The teacher enables students to use sources of geographical information as evidence.</p> <p>Students:</p> <ul style="list-style-type: none"> • search for information • collect evidence • select evidence • sort information • classify information 	<p>Inquiry is reflective</p> <p>The teacher provides opportunities for both students and teacher to reflect on learning.</p> <p>Students are critical in relation to:</p> <ul style="list-style-type: none"> • sources of information • skills and techniques used • criteria for making judgements • opinions • what has been learnt • how it has been learnt • how the inquiry could be improved • how the inquiry could be further developed • the value of what has been learnt

Figure 2.6 Essential elements of learning geography through inquiry (Roberts, 2013)

Chapter 3: Design

3.1 Introduction

Following a detailed review of the literature relating to higher-order thinking, geographical thinking and inquiry-based learning in geography, the researcher designed a technology enhanced inquiry-based learning experience which aimed to encourage participants to use and develop higher-order thinking skills. The researcher aimed to incorporate the key elements of a geographical IBL activity as outlined by Roberts (2013) into the design of the activity. The researcher also referred to the essential and optional elements of an IBL outlined by Spronken-Smith *et al.* (2008).

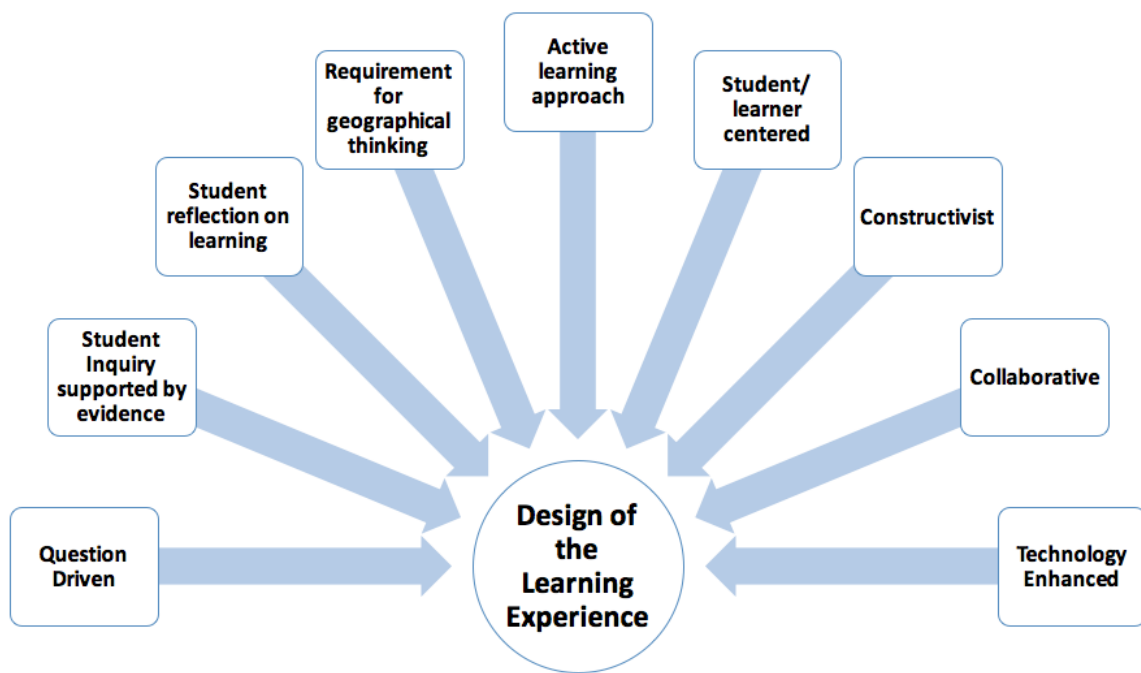


Figure 3.1 Themes emerging from the literature review that were incorporated into the design of the learning experience.

3.2 Description of the Learning Experience

The learning experience itself consisted of three key elements. The first element was a city design exercise (referred to as the 'design-a-city' activity in this report), the second element was a VFT experience which allowed participants to explore four cities around the world using a variety of web-based tools. During both of these elements of the experience, participants worked in groups of three or four. Data was collected at a number of points throughout both of these elements of the activity. The collection of data and methods of analysis will be outlined further in Chapter 4 (Methodology). The third element of the activity was the creation of a concept board using a Padlet wall. The following is a detailed description of the three main elements of this learning activity.

Element 1: Design-a-City Activity

This activity involved the participants designing a city. The activity involved a base map onto which the participants placed various squares which represented the major land use zones found within a city (see *Fig 3.2*). The participants worked in groups of three or four to complete this activity. The aim of the exercise was to allow the participants to explore some of the issues of urban planning such as urban sprawl, social stratification, traffic congestion and public transportation.

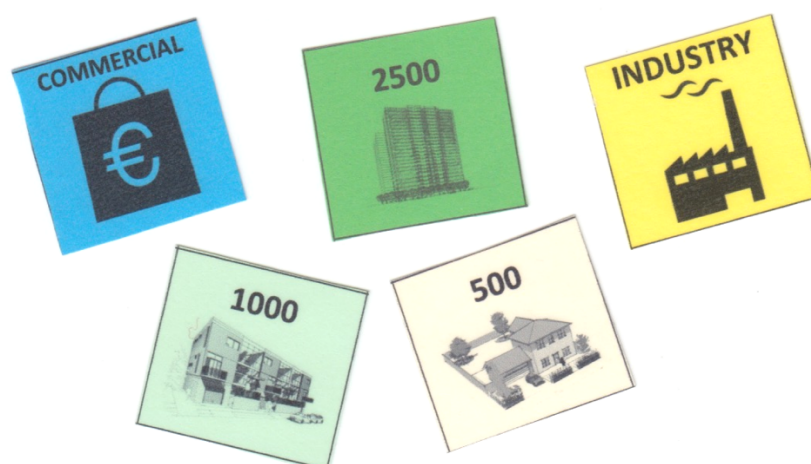


Figure 3.2 A sample of the land use squares used to plan a city

The participants were given a brief introduction to the activity which explained the various squares and what they represented. The task was to design a city for 50,000 people. The number of people housed in a residential square was printed on each square (as seen in *Fig 3.2*). Each group received a pack of squares which allowed them the flexibility to create a high, medium or low density city. The participants had to assess which type of housing, or mix of housing would be most suitable for their city. There were also 10 commercial and 10 industrial squares to be placed on the map. Finally, the participants had to pick 8 services from a possible 16 to place in the city design. The activity was designed to encourage discussion and analysis and in this way to allow for higher-order thinking.



Figure 3.3 Participants work in groups to design a city during the research activity

Element 2: Virtual Fieldtrip (VFT)

Having designed a city, the participants took part in an online VFT which allowed them to explore four major cities around the world. These cities were Paris, Los Angeles, Hong Kong and Sao Paulo. These four cities were selected by the researcher as they represent four different approaches to urban design and planning and each face a variety of social, economic and environmental issues and pressures. The participants were encouraged to explore these cities using a website built by the researcher for this purpose. The VFT website can be found at www.oururbanfuture.weebly.com.

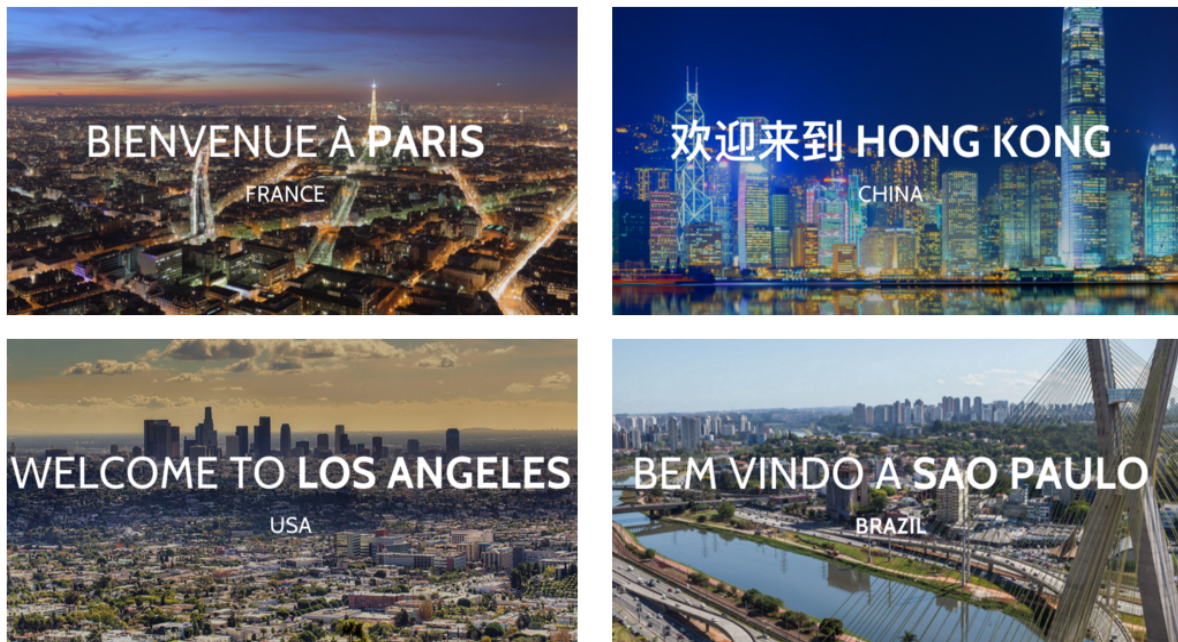


Figure 3.4 The menu of the VFT website showing the four cities that the participants explored during the VFT.

Each of the four cities had a separate page which acted as a portal for students to explore the city using a variety of online tools (See *Fig 3.9* for a screenshot of one of these pages). The following is a description of the online tools that the participants were encouraged to use in order to become familiar with the cities in question.

Tool 1: Google Maps and Street View

The first tool available to the participants to explore the cities was Google Maps and Street View. These tools allowed the participants to examine the location and layout of each of the cities from various perspectives. The map view allowed students to get a sense of the location of each city at a variety of scales. This also allowed students to gain an understanding of the physical layout of the city as well as an understanding of the physical features found close to the city (e.g. coastlines, rivers, bays, mountain ranges etc.)

The map also included a link to the Google Maps website which allowed the participants to explore a 3D map version. This function was highlighted to the participants by the researcher. This allowed for another interesting perspective on the cities in question as shown in *Fig 3.5*. This allowed students to get a clear view on the population density and the form of the city.



Figure 3.5 3D Google Map view showing high density housing in Hong Kong



Figure 3.6 3D Google Map view showing low density housing in Los Angeles

The Street View function allowed the participants to explore the city at street level and to gain a sense of what the city looks like on the ground. This allowed the participants to observe the living conditions and urban form of each city and to observe the economic activities taking place there. The participants were encouraged to place themselves in a variety of locations around the city and to explore these areas to see the differences between areas within each city.



Figure 3.7 Google Street View showing a street in Hong Kong

Tool 2: YouTube

While Google Street View allowed participants to freely explore pictures the city at street level, it lacks the facility to examine the voices and opinions of residents as well as movement of vehicles and people within a city. In order to simulate this aspect of a real-world fieldtrip, a selection of videos were made available to the participants. This part of the VFT gave participants a chance to explore and watch a variety of YouTube video clips about each of the four cities. This allowed the participants to experience the sounds of the city as well as to hear how some local residents feel about their city and the challenges experienced by these residents.

The videos were selected by the researcher with the aim of giving an insight into the lifestyle and movement of people within each city. In each case, two of the videos highlighted issues facing the city and its population while the other two videos provided a factual account of the main sights of the city and a time lapse video showing the movement of people and vehicles within the city.

Tool 3: City Map Comparison Tool (mapmerizer.mikavaa.com)

This tool allowed the participants to compare each of the four cities with any other city. This tool has two scrollable Google Maps placed side by side. The zoom level is the same on both maps and therefore the maps are shown at the same scale. This allowed the participants to gain an understanding of the relative size of each of the cities and to compare each city with their home city or local area.

In this way the participants were able to gain an understanding of the size of each city as well as the population density of each city.

One other interesting and useful feature of this comparison tool is that it allows the user to overlay the traffic conditions in the cities being compared as well as the public transport networks and cycle lane facilities.

COMPARE HONG KONG TO ANY OTHER CITY...

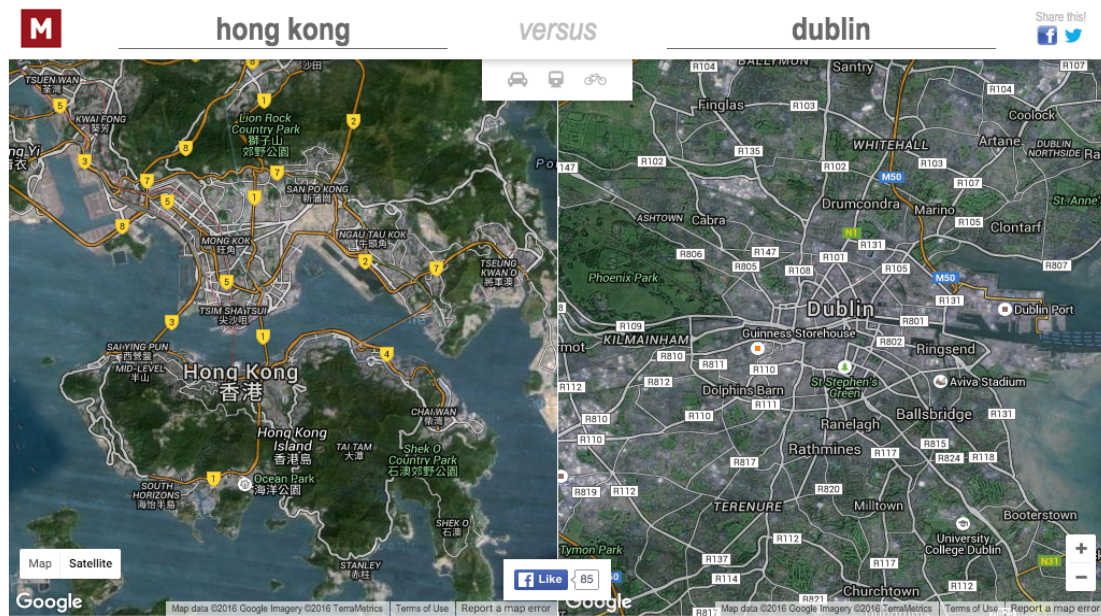


Figure 3.8 City comparison tool showing Hong Kong and Dublin

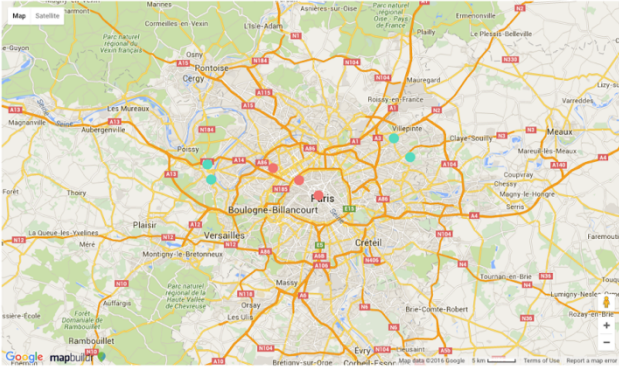
Other Tools

In addition to these main tools, the VFT provided links to a variety of relevant web pages that would give the participants different perspectives on the cities. These links were;

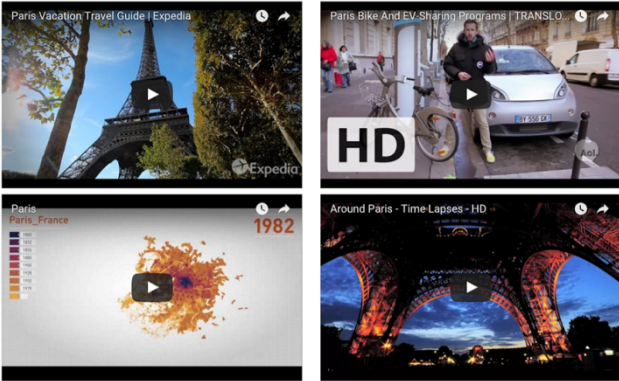
- Flickr photos - this allowed participants to explore tourist's photos of the city. The purpose of this link was to allow participants to see the city from different perspectives.
- Trip Advisor - this allowed the participants to see what tourists were saying about this city.
- 360cities.net - These panoramic photos enabled participants to see inside the buildings and tourist attractions in the city.



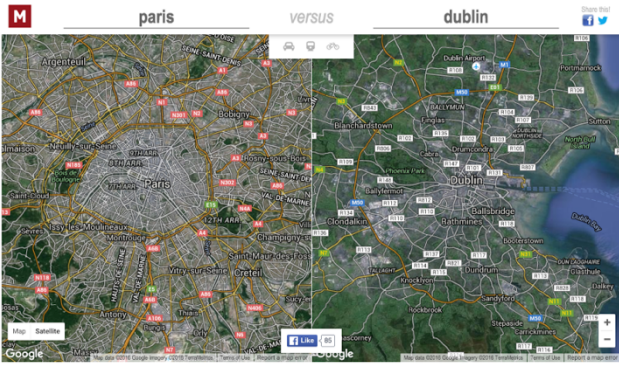
GOOGLE MAPS AND STREET VIEW



VIDEO



COMPARE PARIS TO ANY OTHER CITY...



OTHER INFORMATION

- FLICKR PHOTOS
- TOURIST INFORMATION
- PANORAMIC PHOTOS
- PUBLIC TRANSPORT MAP
- CYCLE ROUTE MAP

Figure 3.9 Screenshot of the Paris VFT portal page

Element 3: Concept Board (Padlet Wall)

Throughout the learning activity, the participants posted their reactions and ideas on a padlet wall. Participants created a concept board outlining ideas that they found interesting about each of the cities that they visited during the fieldtrip. Padlet is a basic and intuitive blogging tool which allows users to create an online 'noticeboard' where ideas can be posted and saved.



Figure 3.10 A sample Padlet wall (Source: <http://www.sonoma.edu/>)

This was included in the design of this learning experience to simulate a field notebook that may be kept during a real-world fieldtrip in order to collect ideas and to reflect on their significance. Reflective field diaries are increasingly seen as an important element of any geographical field-work, especially within human geography. Reflective field-work diaries offer an innovative and flexible approach to teaching, learning and assessment of geography field-work and encourage deeper engagement and analysis of the patterns or processes that are under examination within the field-work exercise (Dummer *et al.*, 2008).

Each group created a concept board showing ideas, designs or features of the cities that they found interesting. A sample of a concept board is seen in Fig 3.11.

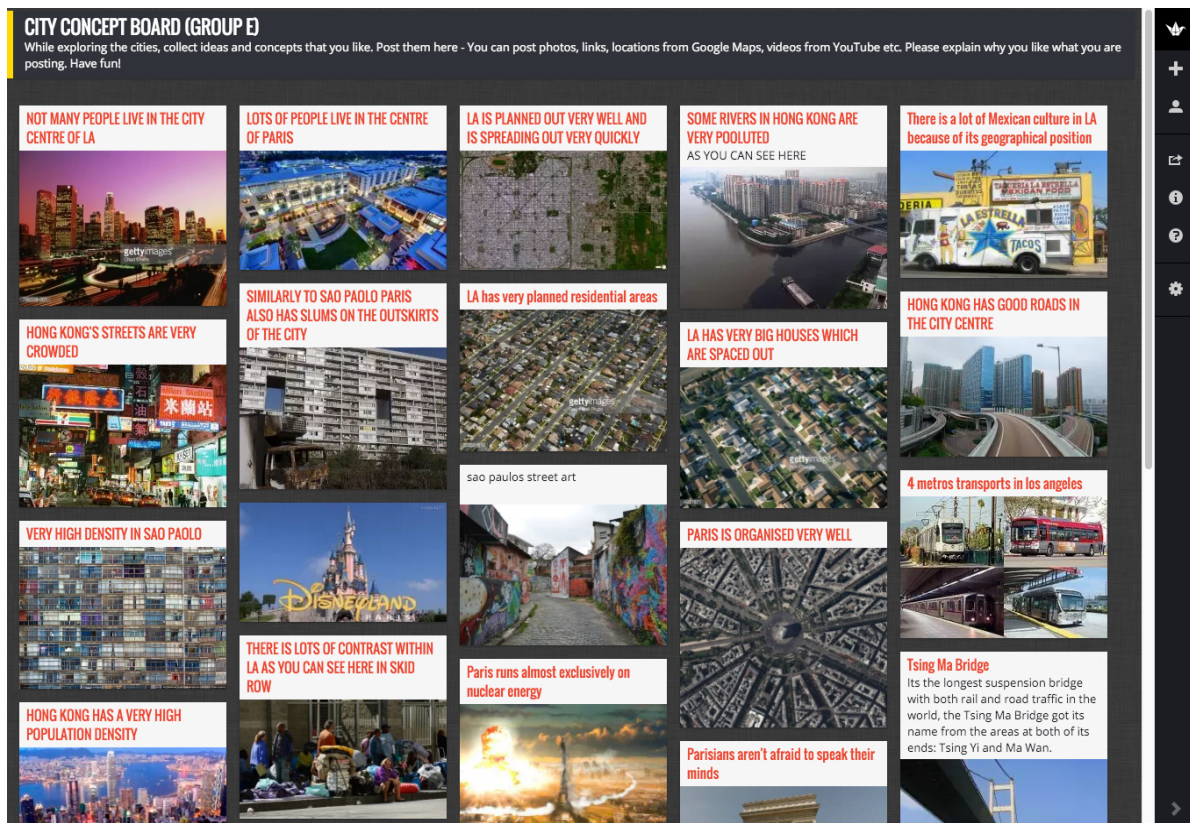


Figure 3.11 An example of a concept board created during the learning experience

3.3 Data Collection during the Learning Experience

Throughout this learning experience data was collected from the participants by the researcher in order to assess the effect of the experience on higher-order thinking skills. This collection of data took place before, during and after the learning experience. One key element of this data collection was an online survey/ questionnaire that aimed to assess the participants higher-order thinking skills as well as their attitude towards geography and the use of technology in learning contexts. A more detailed description and explanation of this process will be discussed in *Chapter 4: Research Methodology*.

3.4 Participants and Ethical Considerations

The participants were the researcher's transition year students, numbering 36 in total. These students were part of two separate class groups. One group was undertaking a geography

module on urban planning while the second group were taking a module on urbanisation as part of a Global Issues course.

Ethical approval was sought and approved for this study. The following groups/ individuals were given information sheets and permission forms to allow the research to take place;

- student participants
- parents/ guardians (as the participants were under the age of 18)
- the principal of the school

These consent forms were distributed before the research began. All information sheets and permission forms are found in *Appendix 2*.

3.5 Conclusion

Having designed a technology enhanced IBL activity, obtained ethical approval and the relevant permission, the researcher implemented the learning experience and collected the relevant data. The data collection and analysis procedures will be outlined in *Chapter 4: Research Methodology*.

Chapter 4: Research Methodology

4.1 Introduction

This chapter will begin by outlining the research questions that were investigated by this research project. A discussion of the research approach, methodology and an explanation of the data collection and analysis will follow.

4.2 Research Questions

The main research question investigated in this project was;

- *How can students' higher-order thinking skills be enhanced through geography in a post-primary context?*

The following sub-questions were also examined;

- *Does an inquiry-based learning approach in geography facilitate the development of higher-order thinking skills?*
- *Does the use of technology impact on student engagement with or attitudes to geography?*
- *How might the use of technology impact on the development of higher-order thinking skills?*

4.3 Research Approach

In order to investigate the research questions, a mixed methods exploratory case study approach was adopted. Case studies entail the detailed and intensive analysis of a single case (Bryman, 2004). Cohen, Manion & Morrison (2011) note that this approach is suitable when the aim of the research is to investigate a phenomenon or process within a particular, real-world context. In addition, this approach also allows for an examination of how a process or phenomenon is influenced by the context within which it is situated (Baxter & Jack, 2008).

Case studies are useful when examining situations that are not easily analysed through numerical analysis alone. This is because case studies recognise and accept that there are often many variables operating in a single case and that an examination of these cases requires a variety of data collection techniques (Cohen, Manion & Morrison, 2011). Therefore, in order to investigate the research questions in this project, a number of data collection methods, both qualitative and quantitative, were employed by the researcher. This mixed-methods approach made use of both quantitative and qualitative methods in order to gain a deeper understanding of the effects of the educational intervention and thus allowed for a more detailed examination of the research questions. A mixed-methods research approach recognises that a combination of qualitative and quantitative methods allows for a more comprehensive investigation of a phenomenon or process. Denscombe (in Cohen, Manion & Morrison, 2011) suggests that a mixed method approach can;

"... (a) increase the accuracy of the data; (b) provide a more complete picture of the phenomenon under study than would be yielded by a single approach, thereby overcoming the weaknesses and biases of a single approach; (c) enable the researcher to develop the analysis and build on the original data ..." (p. 22).

A mixed methods approach allowed the researcher to collect a wide variety of data which facilitated an in-depth investigation of the research questions. The researcher believes that this is a suitable approach when undertaking research on complex phenomena within educational settings.

4.4 Generalisability of the Research

As case studies examine a process or phenomenon within a single real-world setting, it is often argued that such studies have limited generalisability. While this is a valid point and a clear limitation of this form of research, it should be noted that such studies are part of the growing pool of data and that multiple case studies will contribute to greater generalisability over time (Cohen, Manion & Morrison, 2011). This form of exploratory case study research is also useful in uncovering or highlighting areas for further research.

4.5 Reliability and Validity of the Research

When undertaking research, it is important that the methodology aims to maximise the *reliability* and the *validity* of the research findings and conclusions.

Joppe (in Golafshani, 2003) defines reliability as;

"...The extent to which results are consistent over time and an accurate representation of the total population under study" (p. 598)

and notes that validity;

"...determines whether the research truly measures that which it was intended to measure or how truthful the research results are. In other words, does the research instrument allow you to hit "the bull's eye" of your research object?" (p. 599)

The reliability and validity of this form of mixed-methods case study research is dependent on the triangulation of data that is collected from a variety of sources. In this context, triangulation refers to a process whereby the results of a research instrument or strategy are cross-checked against the results collected using another instrument or strategy. Triangulation helps to explain the richness and complexity of human behaviour by studying it from more than one standpoint (Cohen, Manion & Morrison, 2011). In this way, the results of the combined use of two or more research strategies is mutually reinforcing and increases overall reliability and validity of the research (Bryman, 2004).

4.6 Quantitative Data Collection and Analysis

Quantitative data was collected through two separate research instruments. A survey (MTAS) relating to participants' attitudes towards learning with technology was used to help the researcher examine potential changes to the affective domain during the learning activity. The second quantitative data collected was the participants' first and second city designs.

MTAS (GTAS)

The Mathematics and Technology Attitudes Scale (MTAS) is a simple scale for middle secondary years students that monitors five affective variables/ categories relevant to learning mathematics with technology (Pierce, Stacy & Barkatsas, 2007). These categories are mathematics confidence, confidence in using technology, affective engagement, behavioural engagement, and attitude to the use of technology to learn mathematics. This test was originally designed to measure students' attitudes to learning mathematics with technology. However, for the purposes of this research, the questions were modified to measure students' attitudes to learning geography with technology. This adapted MTAS or 'GTAS' questionnaire was administered at the beginning and end of the research process.

The MTAS survey requires participants to respond to 20 statements using a Likert scale (1 - Strongly Disagree to 5 - Strongly Agree). The responses are then grouped into the five categories listed above and the scores added together to produce an overall score for each category. A paired t-test can then be used to test for changes in the five categories;

1. Behavioural Engagement (BE)
2. Technology Confidence (TC)
3. Geography Confidence (GC)
4. Affective Engagement (AE)
5. Geography and Technology Attitude (GT).

A copy of the the modified MTAS (GTAS) questionnaire can be found in *Appendix 1*.

City Designs

As outlined in *Section 3.2 (Description of the Learning Experience)*, the participants produced city designs both before and after taking part in a VFT exercise. The aim of this Design-a-City activity was to assess whether city design/ urban planning concepts were developed as a result of the VFT and whether the VFT experience had an impact on the participants' analysis, evaluation and creative thinking skills. The researcher's assumption is that the creation of a more complex and well developed city design may indicate analysis and evaluation of real world cities and thus help to address the main research question relating to the development of higher-order thinking skills.

Working in 11 small groups, the 36 participants in this study created a pre-fieldtrip city design and a post-fieldtrip city design. Due to the complexity and number of the designs (22 in total), developing a reliable assessment rubric that would measure the quality/ complexity of each city was problematic. It was decided that the most appropriate method of assessment was Adaptive Comparative Judgement (ACJ).

ACJ is a method of assessment in which teacher's professional judgement is used to create a measurement scale and provide feedback on a pieces of work without the use of scoring rubrics or marking schemes. This method is based on the psychological principle that humans are better at comparing two objects against one another than they are at comparing one object against specified criteria (Bisson et al, 2016). Teachers, acting as judges, are asked to compare two pieces of work and state which one is better. From many such comparisons, a measurement scale is created showing the relative quality of each piece of work (Pollitt, 2012).

The method of ACJ is derived from the 'method of comparative judgement' originally proposed by Thurstone in 1927. Thurstone (1927) notes how the method of Comparative Judgement is suitable when assessing the subjective properties of artefacts (such as handwriting specimens or children's drawings). More recently, the concept has been revisited and adapted for use within modern educational contexts (Pollitt, 2012). A web-based application (www.nomoremarking.com) allows teachers to upload specimens of work to a system that allows invited judges (normally other teachers), to compare two pieces of work and decide which is 'better' (see Fig 4.1). Each judge completes a certain number of comparisons and the web-based system then creates a rank of quality.

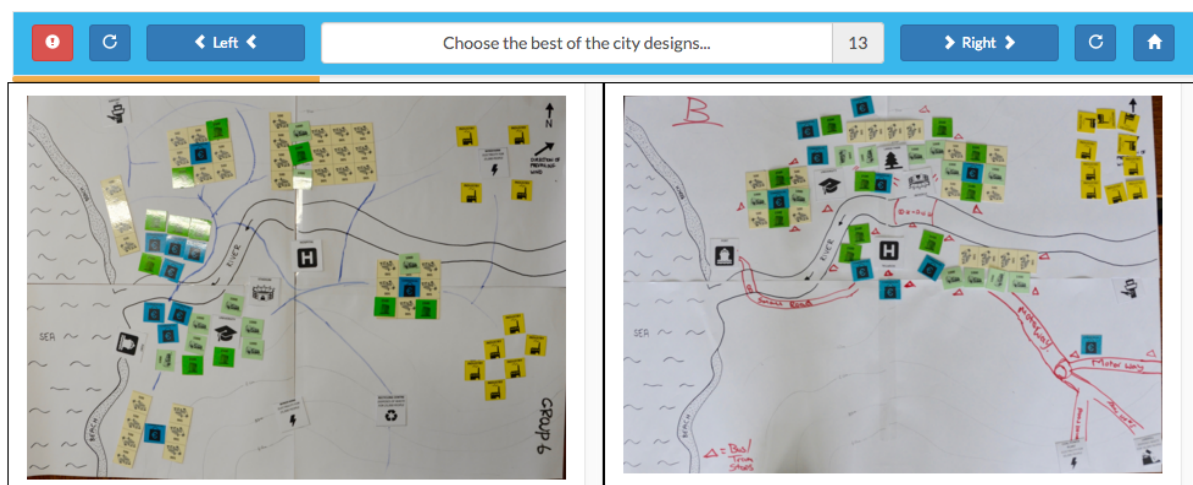


Figure 4.1 Screenshot of a judging session on www.nomoremarking.com

Davies (2008) examines how ACJ is a suitable method for the assessment of e-portfolios in Science. Martin and Lambert (2008) applied the method to the assessment of field-work in Geography. ACJ has also been used in the assessment of Mathematics, English, foreign languages, History, Sociology, Business and Media Studies. Thus, ACJ is a scoring method that has been shown to be effective in many educational contexts (Pollitt, 2012).

In order to assess the city designs, the researcher invited five geography teachers to take part in the ACJ assessment process. Following the rating process, each city was awarded a score, which was used to rank the city designs in order of quality/ complexity. Each city design was also awarded an infit score, which indicates the consistency of the judges' opinion about the design. The teachers who agreed to take part in the judging processes were not aware of whether a given design was a pre- or post- activity design. The teachers were given an information sheet with a brief description of what to look for when assessing the design. This information sheet can be found in *Appendix 3*.

4.7 Qualitative Data Collection and Analysis

Qualitative data was also collected at a number of points throughout this research. The pre- and post-research questionnaire (which included the GTAS survey) was modified to include some open-ended questions to which the participants were encouraged to give detailed written responses. These questions related to both the geographical topic being explored by the participants as well as to the participants' experience of the research itself. A number of groups were also interviewed about their city designs. Recordings of these interviews were analysed and used to triangulate data and to try to explain any relevant changes that occurred between a groups' first and second city design.

Coding of Qualitative Data

One of the challenges of qualitative data analysis is the question of how to reduce large amounts of written data to a manageable and comprehensible amount of information that can be used for analysis. The most common method of achieving this is coding (Cohen, Manion & Morrison, 2011).

Coding involves ascribing a label to a piece or pieces of text that contain an idea or piece of information. Saldaña (2013) notes that;

“A code in qualitative inquiry is most often a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data. The data can consist of interview transcripts, participant observation field notes, journals, documents, literature, artefacts, photographs, video, websites, e-mail correspondence, and so on” (p.3)

All of the participants' open responses were collated and coded using two different approaches. Two different approaches to coding were used in order to assess the data from a number of different perspectives and to gain as much insight into the data as possible. The data was first analysed through open coding and then by a directed form of coding. Each method will now be explored.

Conventional Content Analysis (Open Coding)

The open coding process is often seen as a key tool within grounded theory. Grounded theory is an inductive approach to research. It asserts that theories emerge from the data rather than existing before. Thus a theory is derived inductively from analysis and study of, and reflection on, the phenomena under scrutiny (Cohen, Manion & Morrison, 2011).

During the open coding process, a researcher reads the data and ascribes codes or labels to pieces of text within the data to describe and categorise its meaning. Open coding can be performed on a line-by-line, phrase-by-phrase, sentence-by-sentence, paragraph-by-paragraph or unit-of-text by unit-of-text basis. The codes generated through this process can then be grouped into categories. Each category is then given a title or name by the researcher, based on criteria that are decided by the researcher. The categories can be assigned based on a specific theme emerging within the data, based on similar words within the text or based on similar concepts or similar meanings (Cohen, Manion & Morrison, 2011). The categories can then be used to explore themes and concepts emerging from the original data these themes and concepts can then sometimes be used to devise a theory. *Fig 4.2* shows the process open coding from code, to category, to themes/ concepts and eventually to theory.

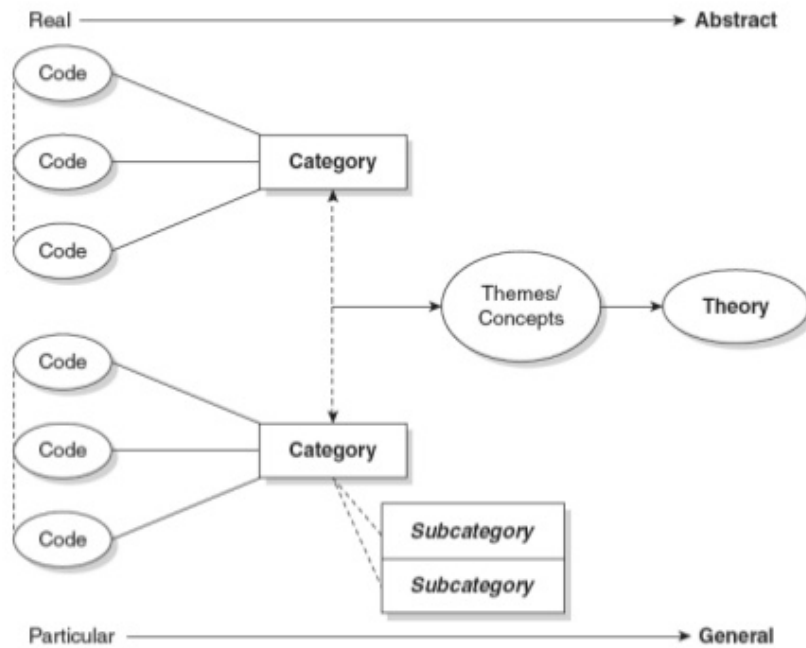


Figure 4.2 A streamline codes-to-theory model for qualitative inquiry (Saldaña, 2013)

Open coding is also known as conventional content analysis. As previously discussed, in this process, the categories emerge out of the analysis rather than through preconceived categories being imposed on the data (Hsieh, & Shannon, 2005). As a result, open coding is usually used as the earliest, initial form of coding undertaken by the researcher (Cohen, Manion & Morrison, 2011).

As part of this research project the data was coded and categories devised. These categories were then used to explore and address the research questions. An example of the open coding process can be seen in *Appendix 4*.

Directed Content Analysis (Directed Coding)

Content analysis using a directed approach is guided by a more structured process than in a conventional (open coding) approach. This method is appropriate when the goal is to validate or extend conceptually a theoretical framework or theory (Hsieh, & Shannon, 2005). Using an existing theory or prior research, researchers begin by identifying key concepts or variables as coding categories. Next, operational definitions for each category are determined using the theory. The data is then analysed using these pre-determined codes.

This method is relevant to this research project as one of the research questions relates to Bloom's Taxonomy of Educational Objectives and seeks to explore how higher-order thinking skills be enhanced. Bloom's Taxonomy is made up of well defined categories (Understanding, Applying, Creating etc.). These categories were used as pre-determined codes which were applied to the data. The pre- and post- intervention surveys were analysed with these categories in mind and examples of each category identified and counted. The categories used for directed content analysis and coding can be seen in *Fig 4.3*.

An initial intention of this research was to assess students' ability to use higher-order thinking skills. With this intention in mind, the researcher devised a framework for assessing levels of each category of Bloom's Taxonomy. Each category (i.e. applying, evaluating, creating etc.) was further subdivided into three levels to represent different levels of each skill (see *Fig 4.3*). The concept was to assess the quality or complexity of the analysis, evaluation or creative thinking and thus see if the activity gave the students a greater ability to implement such skills to a greater extent. However, as the coding was taking place it was decided that coding for the 14 sub-categories was problematic. In the absence of an easily applied operational framework for this purpose, it was decided to code using the main categories of the taxonomy. Thus, the six levels of the taxonomy became the categories for directed coding purposes rather than the 14 subcategories that had been devised.

Focus Group Interviews

The focus group interviews were recorded during the research process. However, it was decided by the researcher that these recorded interviews did not contain significant amounts of additional useful data after the city designs and online questionnaire were analysed. In addition to this, logistical and time limitations precluded an in-depth analysis of the interview recordings. It was decided for the purpose of this project that the focus group interviews would be used simply to backup the findings that emerged from the data collected through other means, namely the city designs and the online questionnaire. Therefore, having analysed the data using the previously outlined procedures, the researcher listened to the focus group interview recordings and specifically sought further information relating to the key findings of this research.

Creating	Use information to create something new
CR1	Answer shows a creative interpretation of the stimulus and/or a solution to the relevant problem/ issue
CR2	Answer shows a creative interpretation of the stimulus, but no solution/ resolution
CR3	Some innovative or creative approach/ solution demonstrated
Evaluating	Critically examine information and make judgements
EV1	Evaluation of a geographical issue, well reasoned and well formulated
EV2	Evaluation of a geographical issue, but some gaps/ errors in evaluation
EV3	Evaluation of a geographical issue, but vague or outlined in brief
Analysing	Take information apart and explore relationships
AN1	Analysis of a geographical concept/ issue, well reasoned and formulated
AN2	Analysis of a geographical concept/ issue, but some gaps/ errors in analysis
AN3	Analysis of a geographical concept/ issue, but vague or outlined in brief
Applying	Use previously obtained information in a new (but similar) situation
AP1	Geographical concept/ knowledge applied, correct application of a relevant geographical term/ concept
AP2	Geographical concept/ knowledge applied, but not fully formulated
AP3	Geographical concept/ knowledge applied, but not well formulated
Understanding	Understanding and making sense out of information
UN1	A description of a relevant issue/concept identified
Remembering	Find or remember information
RE1	Naming a relevant issue/ concept of the stimulus, but with no associated analysis or evaluation

Figure 4.3 The categories used for directed coding for each level of Bloom's Taxonomy.

4.8 Summary and Conclusion

During this research, several sets of data were collected and analysed during this research. The adapted MTAS questionnaire provided quantitative data which was statistically analysed using a paired t-test to test for statistically significant changes to the five separate MTAS/GTAS categories. The city designs were analysed through adaptive comparative judgement with the

assistance of five geography teachers. The open question responses of the online questionnaire provided large amounts of qualitative data which was analysed using two different coding approaches.

All of the data collected during this research was analysed and the used to examine the research questions. In order to increase the validity and reliability of this research, the themes and findings emerging from the data were triangulated. Through triangulation of the data, the researcher aimed to capture any change that would help to answer the research questions.

Chapter 5: Findings & Analysis

5.1 Introduction

This section will outline and analyse the results obtained during this research. The section will begin by outlining the quantitative results obtained from the adapted MTAS (GTAS) questionnaire and the Design-a-City activity. Following this, the results of the qualitative data obtained from the online questionnaire and the focus group interviews will be outlined and discussed.

5.2 MTAS/ GTAS Results and Analysis

The raw data generated from the adapted MTAS questionnaire was entered into Microsoft Excel. This data consisted of a series of Likert scale results ranging from 1 to 5 for twenty different questions. The responses were grouped into the five MTAS subcategories - Behavioural Engagement (BE), Technology Confidence (TC), Geography Confidence (GC), Affective Engagement (AE) and Geography and Technology Attitude (GT). The Likert scale results for the four questions relating to each category were added together and an overall subcategory score was obtained in each case. This was done for both the pre- and post-activity questionnaire responses in order to allow for a test of statistical significance. Within Microsoft Excel, a paired t-test was then used to compare the pre- and post- activity scores for each category. A paired t-test is useful when testing for statistically significant differences within a pre- and post- test scenario (Cohen, Manion & Morrison, 2011).

The results of a paired t-test show whether the difference between means is statistically significant and whether the null hypothesis can be rejected. The t-test function in Microsoft Excel calculates a critical t-test value. A critical value is a point on the test distribution that is compared to the test statistic to determine whether to reject the null hypothesis, and thus indicate whether the difference is statistically significant. If the absolute value of the test statistic (t-value) is greater than the critical value, you can declare statistical significance and reject the null hypothesis (Minitab, 2016).

Having performed the paired t-test on the MTAS data, it was clear that it did not indicate any significant changes within the five MTAS categories. As shown in *Table 5.1*, the absolute value of the test statistic (t-value) is not greater than the critical t-value in any of the categories. As a result, no further statistical analysis was undertaken using this data.

	Mean	Variance	t-value	p-value	Critical t-value
BE PRE	15.42857143	5.605042017	0.905623627	0.371508356	2.032244509
BE POST	15.05714286	6.761344538			
TC PRE	14.60	11.77647059	0.223936358	0.824147029	2.032244509
TC POST	14.45714286	13.0789916			
GC PRE	15.05714286	9.408403361	-1.222406668	0.229960579	2.032244509
GC POST	15.60	9.364705882			
AE PRE	15.62857143	8.005042017	-0.910182055	0.369134228	2.032244509
AE POST	16.00	7.235294118			
GT PRE	14.51428571	13.72773109	-1.138687916	0.262793202	2.032244509
GT POST	15.02857143	13.02857143			

Table 5.1 Statistical analysis of the adapted MTAS survey showing the t-values and the critical t-values for each of the five MTAS subcategories.

These results were unexpected and indicate little or no change in the participants' attitudes towards learning geography with technology. This was surprising to the researcher due to the positive feedback obtained from students at other points throughout the research. As discussed in *Section 5.5*, the student's attitude towards the experience was mainly positive and participants reported high levels of engagement with many elements of the activity.

A possible reason for the lack of a significant change within the MTAS data may be that the post-test questionnaire was performed almost two weeks after the end of the research activity. This occurred due to time constraints relating to the school calendar. As a result, the final questionnaire was undertaken after a mid-term break. This may mean that the participants' experience of the research seemed distant by the time they filled in the post-activity MTAS

questionnaire. The researcher believes that the feelings of engagement and enjoyment reported at other stages throughout the research were less strongly felt by the time the second questionnaire was completed.

The MTAS is also designed to measure attitudes to learning mathematics through technology. It has been shown to be a highly effective tool for this purpose. It may be that when adapting the questions to suit geography, the accuracy of the tool was affected. The researcher will discuss the need for developing an effective GTAS questionnaire in *Section 6: Discussions and Conclusions*.

5.3 Design-a-City Results and Analysis

The results from the Design-A-City activity come from the adaptive comparative judgment (ACJ) process. Having been rated by five geography teachers, the designs were awarded a number of scores/ values. The most relevant and useful of these are the scaled score and the infit value.

- **The scaled score** is similar to a traditional grade (marked out of 100). This score allows the researcher to quantify the quality/ complexity of an artefact on a scale that is easily interpreted, and to compare artefacts to each other.
- **The infit value** measures how consistently a design was rated by all five judges. Infit values of 1 or below represent a high consistency of opinion between judges. Infit values of above 1.2 suggest inconsistency. Therefore, a high infit score (> 1.2) suggests that the judges had differing opinions about the quality of a city design (Wheadon, 2006). The average infit value of 0.87 indicates a high level of agreement between the judges in this case. Only one of the twenty-two city designs was inconsistently rated and obtained an infit value of 1.23.

During the ACJ process, each judge completed 50 comparisons between two city designs. This equated to 11 judgements per item which was over twice the suggested number of comparisons for a reliable result (the application suggested 5 judgements per item). This produced a reliability score of 0.89 where values range from 0.0 (all noise) to 1.0 (perfect repeatability). Values over 0.80 suggest that the resulting measurement scale is likely to be stable and repeatable (Wheadon, 2006).

In order to allow for anonymity and to facilitate the analysis of the results of this process, each city design will be referred to using a 'City Design Code'. Each group was awarded a letter (i.e. Group A, Group B etc.). The letter in the city design code indicates the group to which the design belongs. Codes ending in the number '1' are the first (or pre-activity) designs and those ending in number '2' are the participants' second (or post-activity) designs.

The ACJ processes returned some very interesting and significant results. *Table 5.2*, shows that the participants' second city designs were rated more highly than their first designs without exception.

City Design Code	Scaled Score	Infit
H2	78.54	1.04
B2	78.21	0.32
J2	65.9	1.16
F2	63.06	0.88
E2	63.05	1.19
K2	60.46	1.05
C2	60.3	0.8
D2	55.91	1.04
L2	55.8	0.63
A2	54.39	0.69
G2	52.74	0.91
F1	48.99	0.67
K1	46.74	0.78
G1	46.7	1.23
B1	41.07	0.7
A1	39.38	0.93
H1	39.23	0.64
J1	33.57	0.41
C1	32.14	0.95
E1	31.52	1.31
L1	30.32	1.12
D1	21.95	0.72
Average	50.00	0.87

Table 5.2 Results of the ACJ sorted by scaled score. Design codes that finish with a number '2' are the participants second city designs.

This simple ranking shows an apparent improvement between the first and second city designs. As shown in *Table 5.3*, the mean score of the first city designs is 37.42, while the second design is 62.76. In order to ascertain if these results are statistically significant, a paired t-test was applied to the data. The t-value obtained was -7.45 and the critical t-value was 2.23. As the absolute value of the t-value is greater than the critical t-value, we can state that there is a statistically significant change within this data. With a p-value of <0.05, it can be concluded that this result is highly significant at the 95% confidence level (*Table 5.3*).

Group	First Design Score	Second Design Score
A	39.38	54.39
B	41.07	78.21
C	32.14	60.30
D	21.95	55.91
E	31.52	65.05
F	48.99	63.06
G	46.70	52.74
H	39.23	78.54
J	33.57	65.90
K	46.74	60.46
L	30.32	55.80
Mean	37.42	62.76
t-value	-7.446624253	
p-value	0.000021	
Critical t-value	2.228138852	

Table 5.3 First and second city design scores compared and tested for statistical significance

These figures show a significant improvement in the overall scores in the post-activity city design. The average increase in score was 25.34. However, as seen in *Fig 5.1*, the level of improvement varied by group. The groups with the biggest increase in score were Group H (difference: 39) and Group B (difference: 37). These groups' city designs can be seen in *Fig 5.2* and *Fig 5.3* respectively.

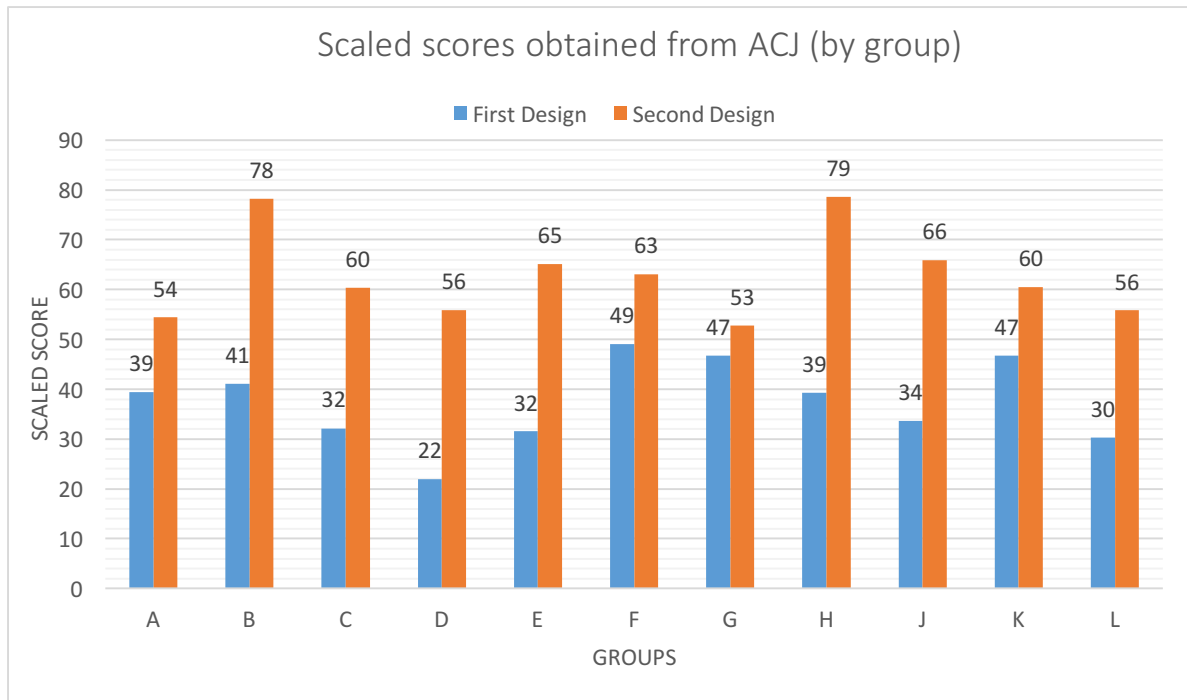


Figure 5.1 Scaled scores of the first and second designs (by group)

Looking at these designs, it is clear that there is a significant change between the first and second attempts for both these groups. The key and notable changes include;

- Reduction in the size of the city mainly resulting from increased density of housing
- Avoidance of large areas of low density or high density housing
- A greater amount of mixed use land zones. For example, an increase in the number of cases of mixed housing densities, or areas of residential and commercial land use
- A more logical choice of services available within the city design and a better location chosen for these services in relation to other land uses
- Commercial land use has been located closer to the residential land use zones
- Evidence of a mass public transport system replacing/ reducing the requirement for roads

Many of these changes represent a significantly improved urban design. The changes indicate an awareness of issues that may lead to a poorly functioning urban areas and indicate that the participants are aware of the connections between a number of aspects of city planning (e.g. housing density and transportation).

H1

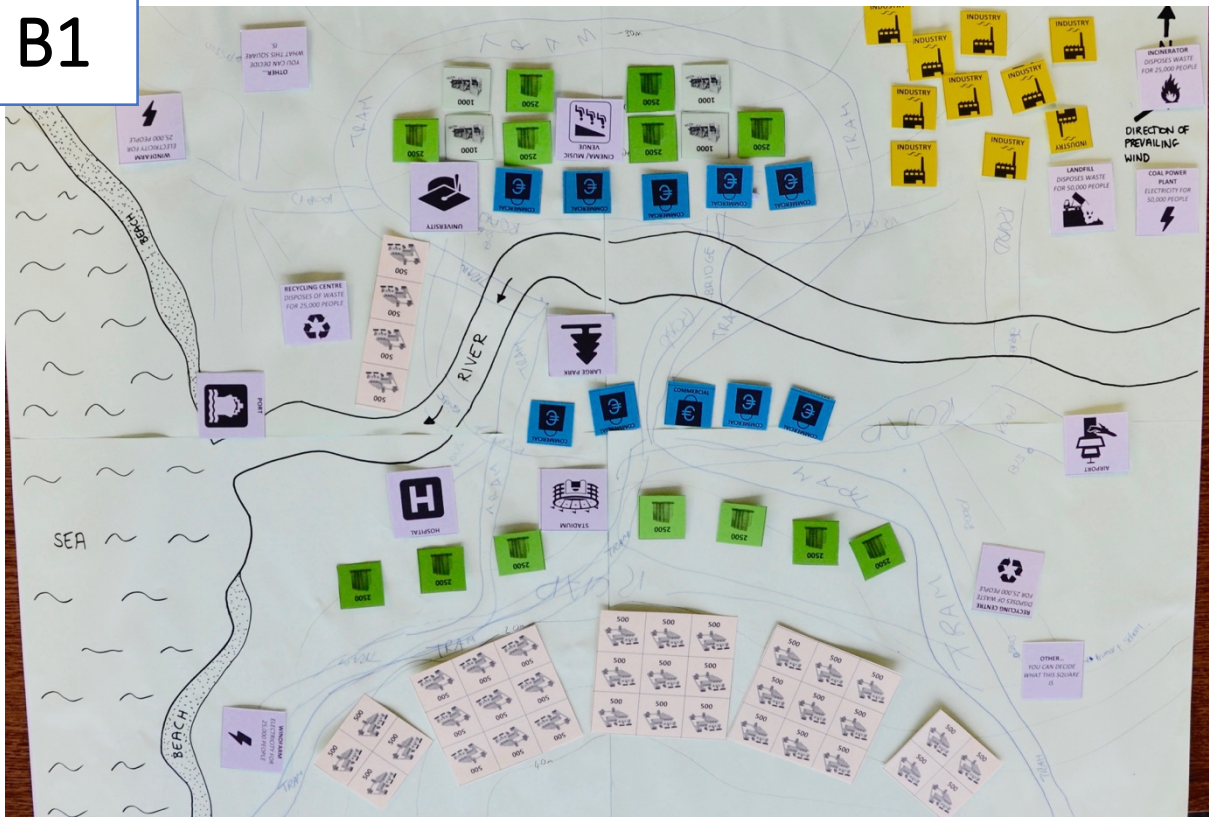


H2



Figure 5.2 City Designs H1 and H2

B1



B2



Figure 5.3 City Designs B1 and B2

While it is evident that the city designs have improved significantly overall, it is important to consider the reasons for this change. It is possible that the designs improved due to the fact that it was the second attempt and that the participants were more familiar with the city design activity itself rather than as a result of any other part of the experience.

In order to address this issue, the focus group interview included a section where the participants were presented with a copy of their first and second designs and asked which city design was better, what changed between the two designs and why they changed the design in that way. If they were able to answer these questions successfully, the researcher probed deeper in an attempt to ascertain the reasons for the changes and the source of any new viewpoints or ideas relating to urban planning. Some interesting responses are as follows;

“The first design we did has no public transport... the reason we put in public transport here [second design] is because when you look at cities like LA it is really congested and difficult to get around”

“We have a bike system because that makes it easy to get around... we have that in Dublin, and I think we saw that in France, yes they have that in Paris”

“We saw in Sao Paulo that they are all low density and for the rich... so we didn't want that to happen so we put in a mix of housing”

“Everything is really compact on the second one... the first one is very divided between wealth classes...but in the second one everything is together, everyone can afford to live in the same areas, the city has more room to grow in the future and everything is together so everything is more accessible, less traffic because there is more public transport”

“I'd say our second city is a mix of something like Hong Kong and Sao Paulo... because Hong Kong is very high rise and high density and Sao Paulo has a lot of low density areas, so we thought it was good to have a mix”

“Our first city is like Los Angeles because it is more spread out... this city would be expensive because of all the roads you have to build”

“the shops are beside the houses [in the second design], everyone can get to them but in the first one the shops were ages away... its [the second design] sort of like Paris I think”

“the second one [design] more organized, it has a lot less houses - well low density ones in the second one... because in Los Angeles, there are big problems of traffic and roads and we didn't want that”

“[we made the second design more mixed density because] ... we saw in some of the cities we were looking at like Sao Paulo had some of that [mixed housing densities] ... it gets rid of the rich thing and poor thing and makes it more mixed”

These responses highlight a number of interesting concepts.

- A significant number of the responses referred to the cities of the VFT. Therefore, it seems likely that the experience of the VFT activity strongly influenced the second city design.
- Participants referred to human/economic as well as to the physical aspects/layout of a city design. Human/economic elements such as class divisions/ social stratification are relatively complex concepts and the researcher finds it surprising that this was noted and addressed by so many of the groups following the VFT.
- The participants' ability to connect elements of their own city designs to the cities of the fieldtrip was also of interest. Many participants explained their city designs by referencing the cities they explored on the VFT.
- Many of the second city designs were explained a 'mix' of two or more of the cities explored. This shows that the participants were able to analyse and evaluate the cities and create a new city design based on their own findings.

These findings and their implications to the research questions will be discussed further in *Section 6: Discussions and Conclusions.*

5.4 Questionnaire Results and Analysis

As well as the adapted MTAS questions, the questionnaire included several open-ended questions relating to the geographical topic at the centre of this study, namely urban planning. These questions were included in the questionnaire to examine the participants' ability to think geographically and to identify issues that arise within particular urban designs.

Once all the responses had been collected, the researcher reviewed the data and used coding to analyse the participants' responses. Open coding was used in an attempt to examine changes in the participants' ability to engage with and explain geographical issues. Directed content analysis was used in an attempt to categorise the participants' responses in relation to Bloom's Taxonomy.

Conventional Content Analysis (Open Coding) for Geographical Thinking

There were four questions within the questionnaire that were designed to test for geographical thinking. These four questions aimed to achieve this by asking the participants to outline their thoughts on a variety of city scenes which were presented in photographs. For example, *Question 1.1* of the survey required participants to outline the pros and cons of a low density housing area (*Fig 5.4*). For the other relevant questions, see questions *1.4*, *2.1* and *2.4* in *Appendix 1*.

Urban Development 1



1.1 Discuss the type of residential area shown in the picture. Can you identify any pros or cons of this type of development?

Figure 5.4 Sample question to test for geographical knowledge/ understanding

It was hoped that the responses to these four questions would indicate the participants' ability to apply geographical ideas and concepts to a real world scenario. In this way these questions would indicate the participants' ability to think geographically.

The responses to these questions were analysed and a code placed next to any word, sentence, idea or concept that was deemed interesting, relevant or important in terms of geographical thinking. An example of the coding processes can be seen in *Appendix 4*. These codes were then combined to form five categories of geographical thinking. These categories were created by combining several different codes as shown in *Fig 5.5*.

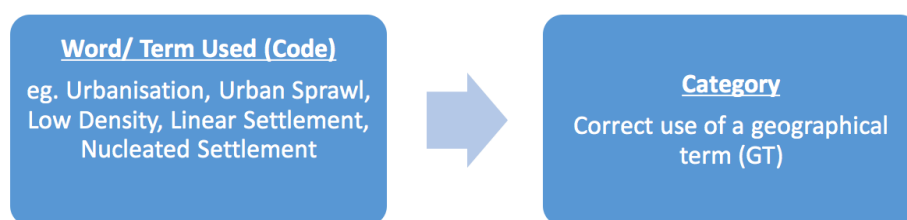


Figure 5.5 The creation of a category by combining a number of codes.

The five categories that emerged from the data were;

- Relevant observation (a relevant statement, but no evident analysis or evaluation) **(RO)**
- Correct application of a geographical term **(GT)**
- Correct application of a geographical concept **(GC)**
- Reference to a relevant example (from VFT cities) **(EF)**
- Reference to a relevant example (other) **(EO)**

The number of occurrences of each category was counted for each of the four questions. The researcher believes that a high rate of occurrence of these five categories within the data, should indicate a more complex, and well developed answer to the question. In other words, a higher level of geographical thinking. In order to facilitate a comparison between the pre- and post-activity answers, the figures are expressed as occurrences per 100 words as the length (word count) of pre- and post-activity questionnaire responses vary significantly. The original data counts have been included in *Appendix 5*.

Overall, all four questions showed evidence of increased geographical thinking between the pre- and post-activity questionnaire (Fig. 5.6).

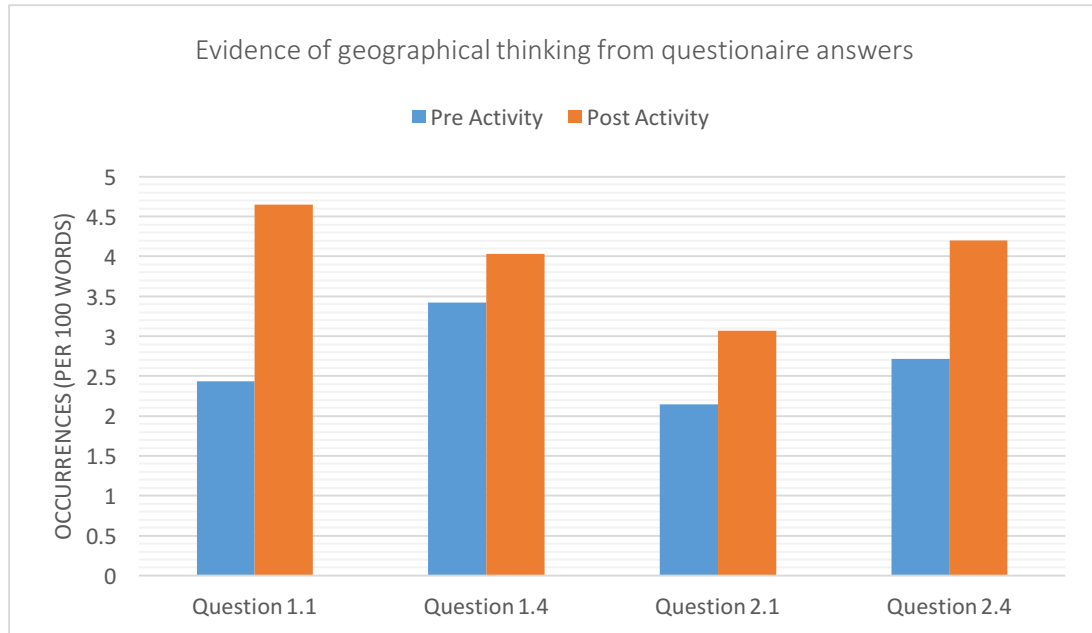


Figure 5.6 Occurrences of the 'geographical thinking categories' by question

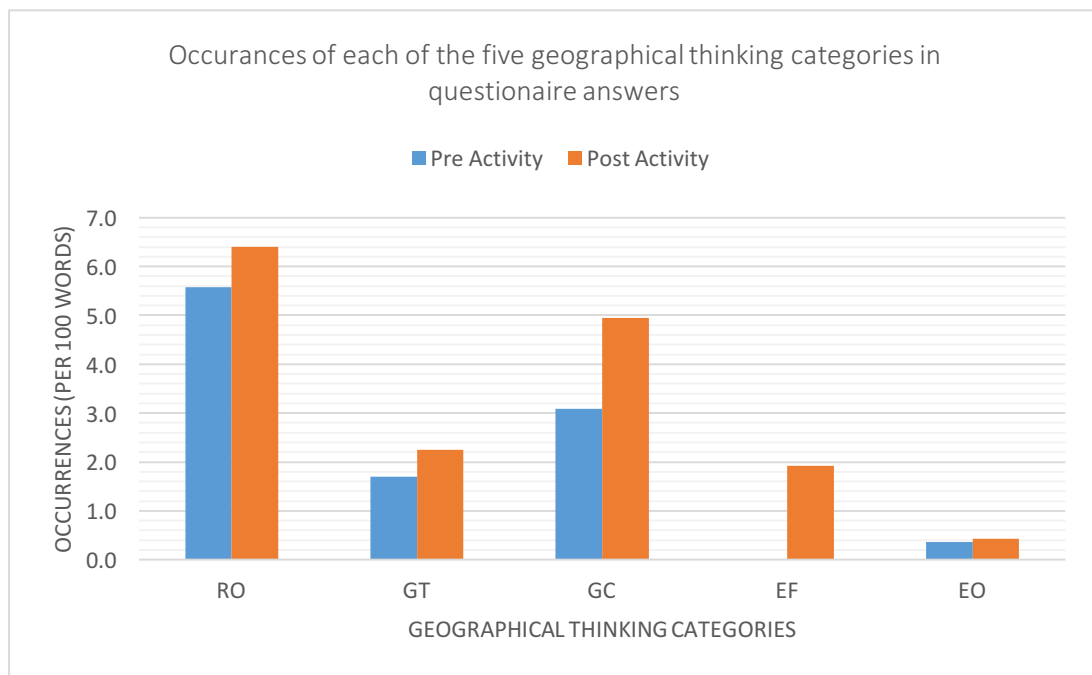


Figure 5.7 Occurrences of each 'geographical thinking' category overall

These results may indicate some interesting patterns within the data. *Fig 5.6* shows that the number of occurrences of the five categories of geographical thinking increased significantly in the post-activity questionnaires. However, while this is possibly evidence of improved geographical thinking and reasoning, the researcher is aware that the difference may be influenced by other factors. These include;

- Familiarity with the questions. This was the second time the participants had undertaken this questionnaire. Therefore, the researcher is aware that a certain amount of the observed change may be attributable to familiarity with the questions.
- An increased understanding of the aims of the research and a desire to give answers that would help the researcher (who in this case has taught these participants previously).

Despite these concerns, the researcher believes that the observed changes are too significant to be attributed to either or both of these factors alone. For example, the number of occurrences of geographical thinking in *Question 1.1* almost doubled in the post-activity questionnaire.

An examination of both questionnaires clearly shows greater detail in the post-activity responses. The researcher believes that the following two examples demonstrate some of the observed difference between the pre- and post-activity responses.

Pre-activity response:

“There are a lot of apartments and offices here. The pros would be that the buildings are so tall more people could live/ work there. The cons would be that... there could be a lot of pollution, also there are an awful amount of people living in such a small space.”

Post-activity response:

“This type of high density development is similar to settlements in Hong Kong. It is good as it allows a large number of people to live in a small space, and makes the most of the area. As the land value is probably quite high it makes sense to build up rather than out. However, there could possibly be problems with air pollution from fossil fuels, from so many people in such a small space. Also there may not be access to much greenery and open land such as parks, which are essential in any residential settlement.”

Both of these responses address similar points. In this case, the high density of housing and the dangers of pollution. However, in the post-activity response, the use of a real world example, the analysis of why the area might be high-rise and an evaluation as to what a residential area should contain indicates a greater amount of engagement with and awareness of the relevant issues and indicates a higher level of analysis and evaluation.

The categories which experienced the greatest increase were the '*use of a real-world example from the fieldtrip*' (increase of 1.9 occurrences per 100 words) and the '*correct application of a geographical concept*' (increase of 1.9 occurrences per 100 words). The categories with the smallest increase were '*reference to an example from elsewhere*' (increase of 0.1 occurrences per 100 words) and the '*application of a geographical term*' (increase of 0.6 occurrences per 100 words). These results are not surprising as this activity focused on the development of higher-order geographical thinking skills which would allow participants to recognise patterns and geographical concepts. The increase in the use of examples from the fieldtrip is also not surprising given the case-study nature of the VFT. The categories that did not increase are also not surprising as this type of activity does little to facilitate the development of geographical terminology.

Directed Content Analysis (Directed Coding)

In order to investigate the thinking skills evident in the questionnaire responses, the data was coded using a directed approach. The categories of Bloom's Taxonomy were used as a framework. The researcher examined the responses and highlighted any sections that showed evidence of any category of the taxonomy. Once a final count figure had been established, the researcher expressed the figures as number of occurrences per 100 words. As previously noted, this was done because the total count values do not take into account the fact that the post-activity responses were significantly longer than the pre-activity responses.

While this process appears relatively straightforward at first, the researcher found it to be highly problematic. Distinguishing between the different categories of Bloom's Taxonomy and identifying examples in the responses was challenging. It should be noted that this will have impacted on the reliability of these results. Often a judgement about a comment had to be made

without being fully clear as to which category the comment should be identified as. Many comments could have been labelled as two or more categories, and the researcher had to decide which code to apply in such cases. This was especially true at either end of the taxonomy, where it was particularly difficult to identify responses that could be labelled “Remembering” or “Creating”.

Creating	Use information to create something new
<p><i>“Places like this should get a bike rental system like in Paris”</i></p> <p><i>“Houses could be put on top of the shops to save space”</i></p>	
Evaluating	Critically examine information and make judgements
<p><i>“these rental bikes are a good type of transport because they do not damage the environment and are cheap”</i></p> <p><i>“This type of building is good because it is using less space as it is going up rather than across”</i></p>	
Analysing	Take information apart and explore relationships
<p><i>“there could possibly be problems with air pollution from fossil fuels”</i></p> <p><i>“living spaces are very crowded in this city because it is high density design”</i></p>	
Applying	Use previously obtained information in a new (but similar) situation
<p><i>“This is similar to the suburban areas in Los Angeles”</i></p> <p><i>“This is a type of linear settlement”</i></p>	
Understanding	Understanding and making sense out of information
<p><i>“Its very spaced out area”</i></p> <p><i>“This looks an area in the suburbs”</i></p>	
Remembering	Find or remember information
<p><i>Any reference to a real example or reference to a fact (with no explanation or analysis) was counted in this category</i></p>	

Table 5.4 Definitions of Blooms taxonomy used for coding with examples taken from participant responses.

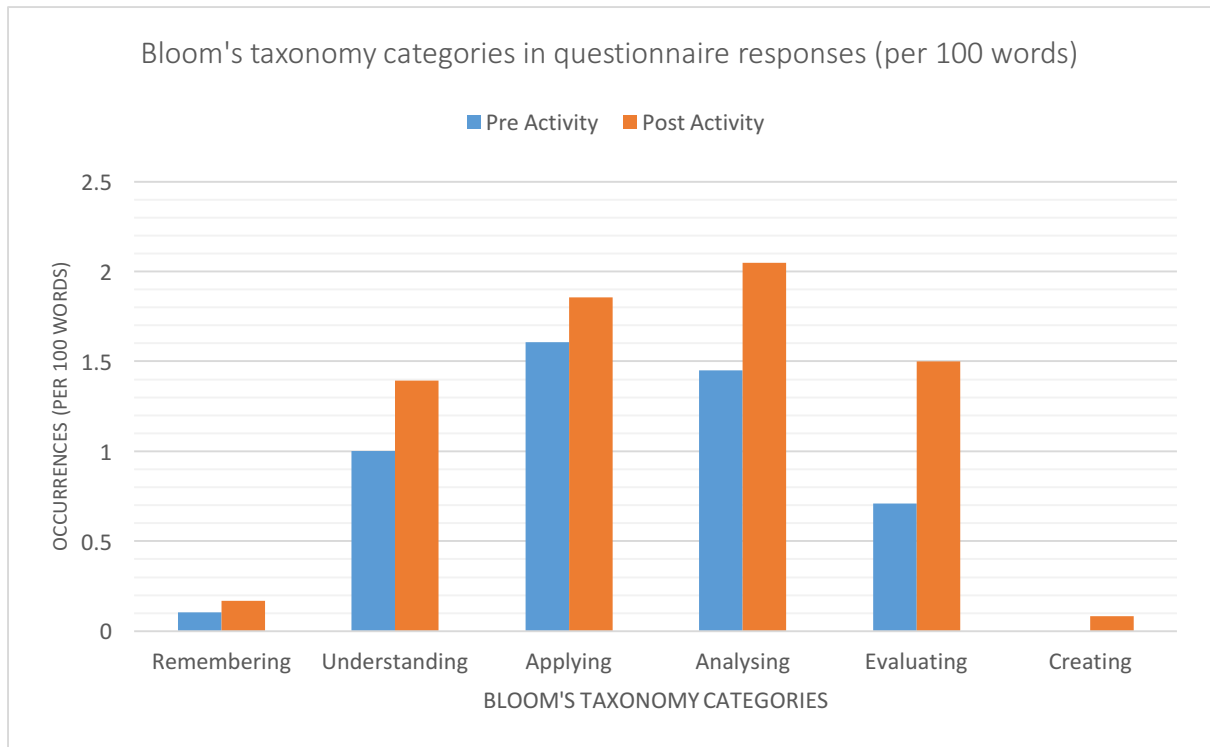


Figure 5.8 Results of directed analysis/ coding

Despite the difficulties experienced during the coding of this data, the data seems to indicate an increase in all six categories of Bloom's Taxonomy. Pre-activity data indicates that the participants were able to apply previously learnt geographical concepts to the situations in question, but often did not provide an analysis or evaluation to the same extent as in the post-activity data. The post-activity data shows a large improvement in the participants' ability to analyse and evaluate the photograph in question. It also shows an improvement in levels of understanding of what is being observed.

Once again, it should be noted that the post-activity results may have been affected by the fact that the participants had already completed this questionnaire and were more familiar with its content.

It is interesting that the category 'creating' was not evident in either set of questionnaire responses. As previously discussed, the participants' city designs showed significant evidence of

analysis, evaluation, and creative thinking. Therefore, it is important to analyse why the “creating” category was not evident in the questionnaire responses. The answer to this question may be the format of the questionnaire itself. Questionnaires may not be a suitable means of assessing creative thinking. The questionnaires were administered online and participants typed their responses to each question. It seems likely that this form of data collection could limit a participant’s ability to express a creative idea. Often creative ideas are difficult to vocalize and so they will not be easily expressed in written form. Therefore, it is important to note that not all thinking processes are captured using this method of data collection. This makes creative thinking a difficult concept to identify and measure.

5.5 Participant Feedback on the Experience

The final section of the post-activity questionnaire related to the participants’ experience the learning activity and of the research. It was important to investigate how the participants felt about what they had experienced and what they had learnt. This section of the questionnaire contained five questions, two closed Likert scale style questions and three open questions.

As shown in *Fig 5.9*, participants reported high levels of enjoyment overall. These results were backed up by discussions the researcher had with the participants during the research which indicated high levels of engagement with the activity and with the topic in question.

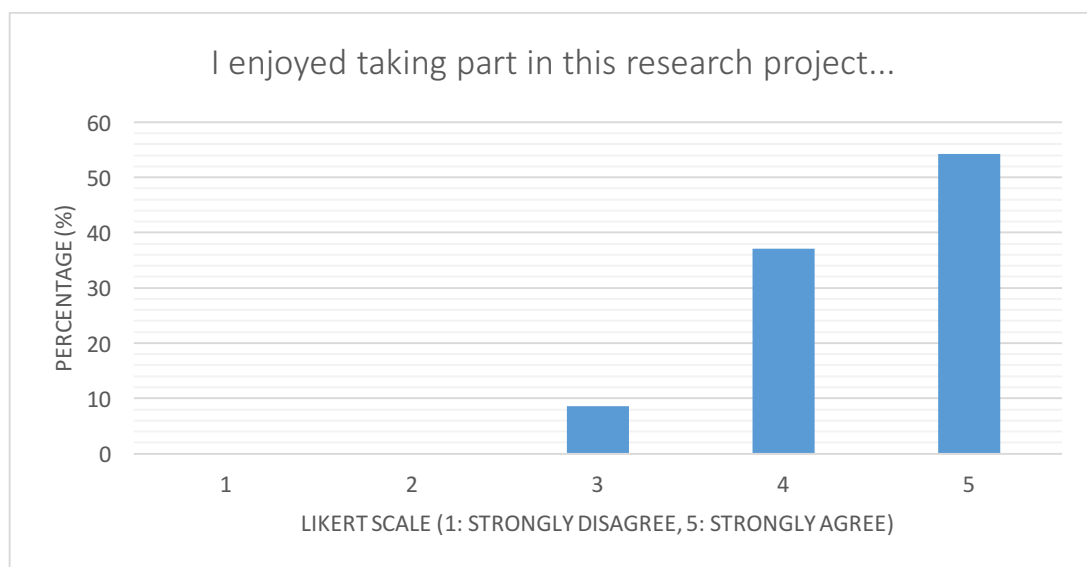


Figure 5.9 Graph showing reported participant enjoyment of the overall activity

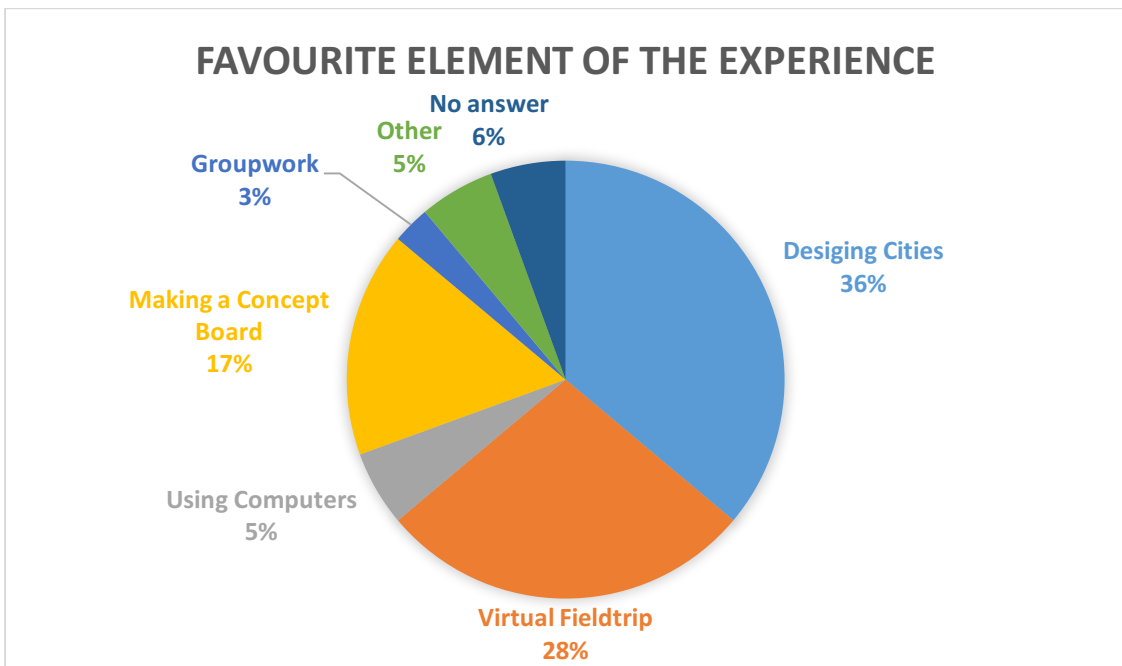


Figure 5.10 Favourite elements of the experience as reported by participants

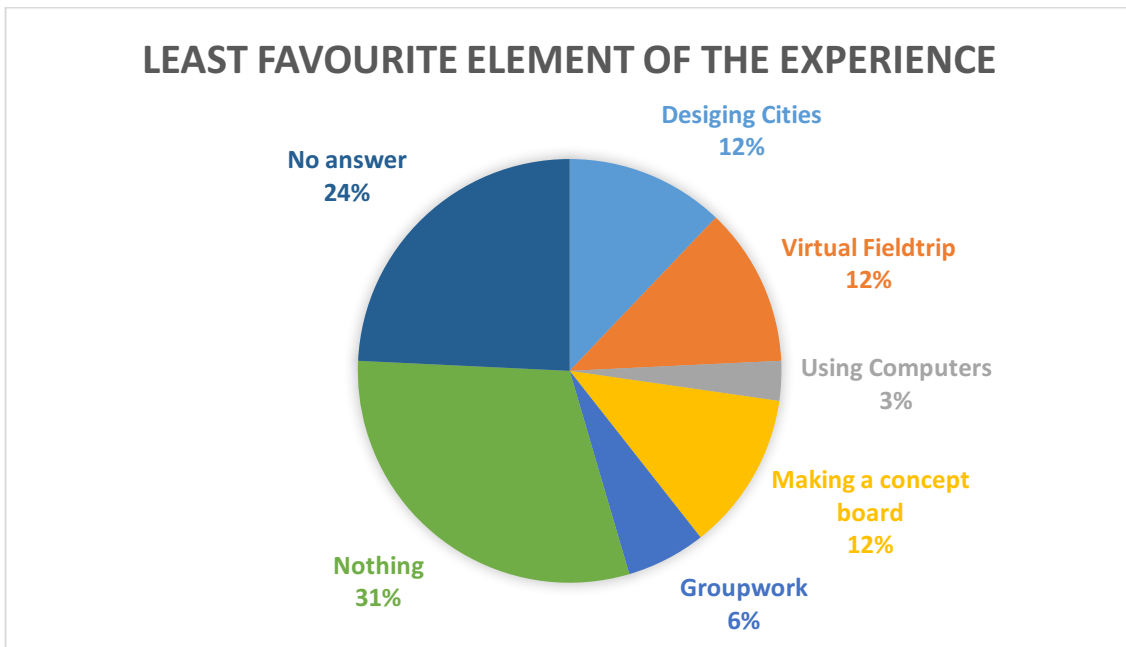


Figure 5.11 Least favourite elements of the experience as reported by participants

Fig 5.10 outlines the elements of the experience that were most enjoyed by the participants. The VFT (28%) and the Design-a-City activity (36%) were the most highly rated elements of the experience. These were the most engaging and interactive parts of the activity and so it is not surprising that this is the case.

Fig 5.11 outlines the participants' least favourite elements of the experience. The most notable results are that 31% stated that they did not have a least favourite element. This is a positive finding and indicates that the experience was well received overall. 24% did not answer this question. There may be many reasons for this and it cannot be assumed that the lack of an answer means that they did not have a least favourite activity. A focus group interview would have allowed for a greater analysis of the overall experience, but due to time and logistical limitations, this was not possible within this research project.

The feedback received from the participants' feedback was mainly very positive. There were a number of elements of the activity that seemed to be particularly well received. These included the self-directed, immersive and interactive nature of the activity.

Many of the participants stated that they enjoyed the self-directed nature of the activity and the freedom to choose what they wanted to explore within the context of the VFT activity;

"we got to find out answers for ourselves and actually see what places are like"

"It was more interactive [than a normal geography class] which made it easier to learn. The research also felt more personal because we were exploring the city on our own"

"I sometimes find it hard to concentrate and read from a book... this experience let me choose what I wanted to learn about and let me look at it the way I wanted to"

Many participants felt that this experience was more immersive and interactive than a traditional class. Participants reported feeling more engaged with the topic and felt that they had developed a better understanding than they may have done in a classroom setting;

"I feel like you got to see a lot more of the different cities than you would in the classroom. Google maps allowed you to look at any different parts you wanted and I feel like I got a better feel for the culture and atmosphere in the cities"

"I got to look at the cities and see what they were like. I saw a lot more of the cities than I would have from a text book or a few powerpoint slides."

"it was different because you got to look around yourself as apposed to being told where to go"

"The lessons were much more practical and engaging"

"we got to explore different regions in more detail than in a traditional geography lesson."

"It was more interactive than usual."

These positive sentiments and experiences are important in terms of the participants' level of affective engagement with the topic and the subject.

Fig 5.12 is a word cloud based on the participants' responses to the question *'How was this experience different to a normal geography lesson'*. These words relate to a number of different factors in both the cognitive and affective domains of learning. This will be discussed further in *Chapter 6: Discussions and Conclusions*.

The Directed coding process was problematic and the researcher believes that these results are questionable due to difficulties experienced when relating the responses to the pre-determined framework. However, the results do seem to indicate increases in the 'analysis' and 'evaluation' levels of Bloom's Taxonomy.

Finally, the participant feedback on the experience was positive. Students reported high levels of enjoyment and engagement with the activity. This is an important finding as these sentiments may have a positive effect on affective engagement with geography.

Chapter 6: Discussion and Conclusions

6.1 Introduction

Following a detailed analysis of the results, it is now possible to address the research questions posed in *Section 1.3* of this project. This section will begin with a discussion of these research questions in relation to the results obtained. Following this discussion, a number of limitations of this research will be examined. This section will conclude with a number of recommendations for future research in the area of higher-order thinking skills within post-primary school settings.

6.2 Addressing the Research Questions

At the outset of this project, four research questions were posed. All of these research questions related to the development of higher-order thinking skills in a post-primary school context. The reason for posing these research questions is that the researcher believes that students of geography at post-primary level are not always given sufficient opportunities to develop their higher-order thinking skills with a curriculum that is content-rich and highly exam-focussed.

Not having sufficient time to develop higher-order thinking skills such as analysis, evaluation and creative thinking is a problem as geography students require these skills in order to effectively engage with many important and complex issues. These include some of the key issues of our time – energy, water, biodiversity, climate, natural hazards, migration, population and urban growth. Geography educators have the import task of helping students to develop the ability to understand, examine and devise complex solutions to these challenging issues and problems so they they can become informed citizens and the decision makers of the future.

The aim of this research was to examine how best to facilitate the development of higher-order thinking skills within post-primary school settings. A feature of post-primary education is the short time-frame of lessons (normally 35-40 minutes) and the gaps between these lessons, which can be up to 3 - 4 days apart. The researcher was interested in how inquiry-based learning could operate within these limitations and if a lack of continuity would be a limiting factor.

Each of the four research questions will now be addressed in relation to the results of this research.

Question 1: How can students' higher-order thinking skills be enhanced through geography in a post-primary context?

The results of this research indicate that the participants' level of higher-order thinking skills improved as a result of this activity. Drawing on the research findings, a number of key features of educational interventions that aim to promote higher-order thinking can be identified.

Inquiry-Based Learning

An inquiry-based learning approach has been seen to be a highly effective means of encouraging students to engage in higher-order thinking. The inquiry process itself can encourage active engagement with an issue or topic and it is through this engagement that students can begin to think more critically and analytically about a topic or issue.

An inquiry-based learning approach begins by creating 'a need to know'. The topic must be relevant and of significance to the students if this 'need to know' is to spark curiosity and a desire to solve the issue/ problem through research and analysis. Once engaged with an issue or topic, an inquiry-based learning approach requires students to support their ideas with evidence. Collecting this evidence provides the opportunity for students to develop analysis and evaluation skills.

Finally, inquiry-based learning approaches should be reflective. Students should be given the opportunity to reflect on their learning, once again, this provides an opportunity for the development of analysis and evaluation skills. In this case, the Padlet concept boards acted as a means of reflection. These helped students to keep track of their findings and to reflect on what they had experienced within the VFT experience. This research shows that the contents of the Padlet concept boards did influence the second city design and was therefore a contributing factor to the development of analysis and evaluation skills.

An inquiry-based learning approach, when correctly implemented, provides a foundation for educational interventions that aim promote the development of higher-order thinking skills.

Freedom to explore ideas and undertake self-directed learning

According to the participants in this research, one of the most enjoyable aspects of the activity was the fact that the learning was more independent and self-directed than what is experienced in more traditional learning environments. Many participants reported feeling free to explore what they wanted to, and feeling that they were directing their own learning rather than following the teacher's plan of action.

Clearly the task had been designed by the teacher/researcher to achieve certain outcomes. However, it is clear from this research that the development of higher-order thinking skills is facilitated by a student autonomy within the learning activity. This is not to say that activities designed to facilitate the development of higher-order thinking skills should lack structure and organisation, but they should allow students the flexibility to explore a topic from a number of different angles so that through their own self-directed exploration of a topic, they will use and further develop their analysis and evaluation skills.

Allowing time for thinking and discovery

Teachers at a post-primary level are often under time constraints to cover large amounts of material in preparation for end-of-term or state exams. This approach to teaching and learning is not always conducive to the development of higher-order thinking skills. This is because these skills are developed over time, and require practice. Within a post-primary context this time is in high demand as large content-rich syllabi must be covered.

The learning activity that formed part of this research involved 8 class periods, and could have been further extended if time allowed. The actual course content covered during the experience was relatively small and possibly could have been taught over 2 class periods using more traditional teaching approaches. However, if this approach had been adopted, the participants would not have had the opportunity to develop their analysis and evaluation skills to the same extent. These are important skills that are transferable and relevant to many different subjects and to life in general.

In order to enhance the development of higher-order thinking skills in a post-primary setting, it is essential that time is allocated for this purpose. It is the opinion of the researcher that inquiry-based learning activities should be integrated across the curriculum in all subject areas. This would appear to be the most practical way of allowing students to develop their higher-order thinking skills within a post-primary context.

The nature of assessment

One of the issues that arose during this research related to the measurement of higher-order thinking skills. It was seen that traditional methods of assessment may not be suitable approaches to the assessment of these skills. This is because creative ideas which require higher-order thinking can be difficult to express in written form, which is the basis of the majority of school assessment at present. Therefore, the nature of assessment must be adapted to reflect this.

The Design-a-City activity was successful in allowing students to use and demonstrate their creative thinking skills. The creation of these designs also required analysis and evaluation skills as students had to make many decisions about the location of the various elements of their city. The resulting city designs are therefore an indication of the students' thought processes during the design activity. However, using these designs as an assessment tool is problematic as it is difficult to devise a means of rating the quality/ complexity of such an artefact from an objective standpoint.

It is for this reason that the researcher decided to use adaptive comparative judgement (ACJ). This form of assessment allowed for a reliable, useful and practical solution to the issue of rating or assessing the city designs. It seems that this method of assessment has huge potential in relation to the assessment of work that is otherwise difficult to measure. It also seems likely that this method of assessment could be used as a method of formative assessment to develop students thinking skills through peer-assessment. Rating their own work against their peers' work requires skills of analysis and evaluation. Therefore, the assessment of work using ACJ may be an appropriate and effective means of giving students an opportunity to develop higher-order thinking skills.

Question 2: Does an inquiry-based learning approach in geography facilitate the development of higher-order thinking skills?

As discussed in the literature review, inquiry-based learning is an instructional model that uses meaningful tasks such as cases, projects, and research to situate learning. This research case-study aimed to employ an inquiry-based learning approach to facilitate the development of higher-order thinking skills. The findings of this research indicate that this was achieved successfully in this particular example.

In designing this learning experience, the researcher attempted to incorporate the four main characteristics of geographical inquiry as identified by Roberts (2013). Through this research, it became clear that all four of these characteristics impacted on the participants' ability to use higher-order thinking skills.

The first characteristic of geographical inquiry is that it should be question-driven. These questions should relate to authentic real-world issues and problems. The questions in this particular example related to the design of an ideal city. It is important that the questions designed to encourage inquiry are relevant and interesting enough to spark enthusiasm from students. A good question should encourage students to search enthusiastically for an answer and in the process they will need to engage higher-order thinking skills.

Thinking geographically is the second characteristic of a geographical inquiry. It is clear from this research that geography provides an excellent context within which to develop higher-order thinking skills. While these skills may be developed in any subject area, geography seems particularly well suited to this form of activity and learning. Many geographical issues can spark interest in students' minds because they are tangible and affect our personal experience of the world. This facilitates high levels of engagement with the subject which in turn may encourage active questioning which can be used as the basis for inquiry-based learning and the development of higher-order thinking skills.

The use of real-world evidence provides meaning to inquiry-based learning approaches. All inquiry-based learning should be backed up by evidence. The requirement for the use of real-world information and evidence means that students have to perform research. Researching is an activity that requires higher-order thinking skills as students search for, collect, select, analyse and evaluate information.

Question 3: Does the use of technology impact on student engagement with or attitudes to geography?

The results of this research did not produce any significant findings relating to this research question.

The results of the adapted MTAS (GTAS) survey were inconclusive and did not show any significant change to the students' engagement with or attitude to learning geography with technology. There was also very little mention of the use of technology in the qualitative data. As a result, this is a question that will require further investigation in order to be addressed.

This may also be an indication that the technological nature of the intervention was not a significant factor in the participants' experience of the research. This is interesting and may indicate a focus on the geographical topic/ issue under investigation rather than on the use of specific technologies in themselves.

Question 4: How might the use of technology impact on the development of higher-order thinking skills?

It should be noted that while there was little mention of the technology in the data, it is the technology that facilitated this inquiry-based learning activity through the VFT. Without the use of technology, this type of activity would not be practical. In this way, this research shows how technology can modify and even allow for substantial redefinition of educational interventions (Puentedura, 2013). It is technology that allows students to access the information and tools that they need to engage in a geographical inquiry without leaving the school environment. Therefore, as the inquiry-based learning activity has been shown to increase engagement with geography and the use of higher-order thinking, it should be noted that technology is a significant factor facilitating this.

Technology (especially online geospatial technology) is the key to allowing for the implementation of inquiry-based learning in geography as it allows for access to a great variety of real-world authentic data. This data takes many forms including maps, images, interactive activities and videos. This almost limitless source of geographical information provides immense opportunity for students to engage with geographical concepts and issues. However, the quantity of data available online may be overwhelming for many students. This study has shown that when presented in an accessible format, learners are facilitated to explore relevant data which can act as a springboard to push them in the right direction for their learning.

The participants of this research enjoyed the freedom to explore the data and information for themselves. In this case the use of technology gave students the power to direct their own

learning and made the experience more student-centred. This is a very positive effect of the use of technology in this context. During the research, the researcher noted that there was very time when the participants were off-topic/ off-task. This indicates a high level of interest and engagement with the activity.

It is clear that the technology, while not the focus of the learning itself, is the tool necessary to enable effective inquiry-based learning in geography. Basic geospatial technology such as Google Maps and Street View engage learners, allow for increased learner autonomy and facilitate inquiry based learning approaches to the teaching and learning of geography.

6.3 Limitations of the Research

There are a number of evident limitations of this research that should be highlighted.

1. One geographical topic examined

In order to investigate the research questions, one geographical topic was chosen and the learning activity based on this topic. The results of this research indicate that this particular activity did facilitate the development of higher-order thinking skills. However, this does not mean that the application of an inquiry-based learning would have this effect on all areas and topics within geography.

2. Limited generalisability

This research project used one group of 36 students as participants. It is often argued that research that takes the form of a case-study automatically suffers from limited generalisability. Although this learning activity had a positive effect on this particular group of students at this particular time, it may not have the same effect on a different group of students, or the same group at a different time. For more accurate results, this activity should be implemented with a variety of groups in different settings. While this is a clear limitation of this form of research, it should be noted that such studies should be seen as part of a growing pool of data and that multiple case studies will contribute to greater generalisability over time (Cohen, Manion & Morrison, 2011).

3. Lack of a follow-up activity and/or focus group interview

This research was influenced by time limitations. The researcher was teaching this class for six weeks only. It would be interesting to implement a follow-up activity and focus group interview to assess whether the changes observed were still evident after more time had passed. Interviewing the participants several weeks or months after the experience may allow for a more accurate assessment of the longer-term impacts of this activity on the participants' higher-order thinking skills.

4. Limited validity of research instruments

In order to assess the research questions posed in this project, the researcher devised a number of research instruments to collect data and decided on methods of analysis that seemed appropriate in each case. While the accuracy of some of the research instruments and methods (especially the directed content analysis) has been questioned and discussed in a previous section of this project, it should be noted that all results in this research project should be treated with some caution due to the fact that they have been obtained using unvalidated research instruments. For example, an assumption was made, that the complexity of the city designs reflected the participants' level of analysis and evaluation skills. While this may be the case, it has not been validated and so these research instruments and methods would require further attention in order to increase their validity.

6.4 Recommendations for Future Research

During the completion of this research, a number of issues arose that the researcher feels requires further attention.

1. Developing a higher-order thinking assessment tool for geography

It is surprising that there appears to be a lack of an operational assessment tool for higher-order thinking in geography. Despite extensive research, the researcher was unable to find a framework for assessing written work in relation to the six categories of Bloom's Taxonomy. The creation of such a framework would allow educators to identify examples of each category of the taxonomy within a piece of written work.

2. Development of a validated GTAS questionnaire

The MTAS questionnaire has been shown to be a highly effective means of assessing students' attitudes to learning mathematics using technology. While efforts were made in this research to adapt the MTAS to suit geography, it appears that this attempt may not have been successful. The development of a validated GTAS would be extremely useful for teachers of geography.

3. Measuring creative thinking

Further research into ways of measuring creative thinking within geography is required. This research found that the use of questionnaires and surveys may not be an effective method of assessing or measuring creative thinking. This is due to the fact that it can be difficult to expressing creative thoughts in written format. Further research on practical methods for the measurement and assessment of creative thinking within geography is required.

4. Cross-Curricular Inquiry Based Learning Activities

The value of IBL activities is by no means unique to geography. The researcher believes that technology-enhanced IBL activities may be most effective if used in a cross curricular format. The researcher can envisage IBL activities that that are relevant to geography as well as other subjects such as science, mathematics, foreign languages, art and many more. The possibility and effectiveness of such activities should be examined in some more detail.

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Appendices

Appendix 1 – Questionnaire and Adapted MTAS (GTAS)

Section 1 of 7



Geographical Thinking Questionnaire

This survey is to assess what you have learnt during the activities that you have undertaken as part of the research project: Enhancing Geographical Thinking in a Secondary School Setting.

The reason for this questionnaire is to see if the type of activity that you have taken part in has helped develop your ability to think geographically.

The survey is anonymous.

Participation in this activity/ survey is voluntary. You can withdraw from the survey at any time without penalty.

Each question is optional. Feel free to leave any section blank if you don't want to answer the question; however the researcher would be grateful if all questions are responded to.

Please do not name anybody (including yourself) in any of your answers, any such replies will be anonymised.

Conflict of Interest: As the researcher is your teacher there is a conflict of interest.

This survey will take approximately 8 - 10 minutes to complete. The overall project will take approximately 8-9 lessons (three weeks) to complete.

If the researchers find out about any illegal activities during the study they will have to inform the appropriate authorities (the principal of the school).

Please do not name any third-parties in any open text field of the questionnaire. Any such replies will be anonymised

Contact: If you have any concerns or questions about this research, please talk to Mr. Rankin or email rankinc@tcd.ie / rankinc@highschool.ie

Consent

- I know that my parents/ guardians must also sign a consent form in order for me to take part in this study.
- I have read, or had read to me, a document providing information about this research and this consent form.
- I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.
- I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity.
- I understand that if I make illicit activities known, these will be reported to appropriate authorities.
- I understand that I may stop electronic recordings at any time, and that I may at any time, even subsequent to my participation have such recordings destroyed (except in situations such as above).
- I understand that, subject to the constraints above, no recordings will be replayed in any public forum or made available to any audience other than the current researchers/research team.
- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
- I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.
- I understand that my participation is fully anonymous and that no personal details about me will be recorded.
- I understand that if I or anyone in my family has a history of epilepsy then I am proceeding at my own risk.
- I have received a copy of this agreement.
- Data Protection: I agree to Trinity College, University of Dublin storing and using my information from this project for the purposes of research.

Confirm Consent

- Yes - I understand and would like to continue
- No - I would not like to continue

PART 1: Urban Population Density

Please note that each question is optional. Feel free to skip any question; however the researcher would be grateful if all questions are responded to.

Urban Development 1



1.1 Discuss the type of residential area shown in the picture. Can you identify any pros or cons of this type of development?

Long-answer text

1.2 Where do you think this photo was taken?

- Europe
- North America
- South America
- Asia
- Africa
- Other...

1.3 Why do you think that this photo was taken there?

Short-answer text

Urban Development 2



1.4 Discuss the type of urban development shown in the picture. Can you identify the pros and the cons of this type of development?

Long-answer text

1.5 Where do you think this photo was taken?

- Europe
- North America
- South America
- Asia
- Africa
- Other...

1.6 Why do you think that this photo was taken there?

Short-answer text

PART 2: Urban Transportation

Please note that each question is optional. Feel free to skip any question; however the researcher would be grateful if all questions are responded to.

Transport 1



2.1 What are your thoughts on the transportation shown in picture above. Try to explain any pros/ cons that you see and explain why these pros/cons exist.

Long-answer text

2.2 Where do you think this photo was taken?

- Europe
- North America
- South America
- Asia
- Africa
- Other...

2.3 Why do you think that this photo was taken there?

Short-answer text

Transportation 2



2.4 What are your thoughts on the transportation shown in picture above. Try to explain any pros/ cons that you see and explain why these pros/cons exist.

Long-answer text

2.5 Where do you think this photo was taken?

- Europe
- North America
- South America
- Asia
- Africa
- Other...

2.6 Why do you think that this photo was taken there?

Short-answer text

PART 3: Geography and Technology

Please note that each question is optional. Feel free to omit a response to any question; however the researcher would be grateful if all questions are responded to.

1. I concentrate hard in Geography

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

2. When the teacher asks a question I try to think of the answer

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

3. If I get an answer wrong, I work to improve it

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

4. If I can't answer a question, I keep trying different ideas

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

5. I am good at using computers

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

6. I am good at using devices like games consoles, iPods, smartphones etc.

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

7. I am good at solving technical issues

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

8. I can master any computer programs or apps needed for school

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

9. My mind is suited to Geography

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

10. I can get good results in Geography

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

11. I know I can handle challenging work in Geography

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

12. I am confident in Geography

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

13. I am interested to learn new things in Geography

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

14. In Geography you get rewards for your effort

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

15. Learning Geography is enjoyable

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

16. I get a sense of satisfaction when I am able to answer a Geography question

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

17. I like using technology for learning Geography

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

18. Using technology in Geography is worthwhile

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

19. Geography is more interesting when using technology

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

20. Technology helps me learn Geography better

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

21. In Geography I am confident using the internet to find information and resources

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

22. I am able to use different software programmes and interfaces for Geography

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

23. It is easy to become good at using technology for Geography

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

24. When using technology to learn Geography, I am confident that I can do well

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

PART 4: Your experience of the research

Please note that each question is optional. Feel free to omit a response to any question; however the researcher would be grateful if all questions are responded to.

1. I enjoyed taking part in this project

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

2. I feel like I have learnt more than I would have in a more traditional Geography class

	1	2	3	4	5	
Strongly Disagree	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	Strongly Agree

3. My favourite part of the activity was...

Long-answer text

4. My least favourite part of the activity was...

Long-answer text

5. How was this field trip experience different to a typical Geography lesson?

Long-answer text

Confirm Answers

Description (optional)

Please Insert your participant number below

Short-answer text

Confirm Answers

If you are happy with your answers, please confirm your consent for them to be recorded. You may instead wish to exit without submitting your answers.

- Exit with submit - I am content with my answers and wish them to be recorded
- Exit without submit - I do not wish my answers recorded

Appendix 2 – Ethical Application and Approval

Student Information Sheet

Project Title: Enhancing Geographical Thinking in a Post-primary School Setting

Introduction

Teachers are always researching and improving methods of teaching to make sure that students are getting the best education. In this study we want to find out how we can improve the teaching of Geography by using technology. The study will give us a chance to see if the using technology and the Internet can improve your understanding of Geography. I am undertaking this research as part of my studies on the MSc Technology and Learning degree at Trinity College Dublin.

What will happen?

The research experience consists of a series of activities that will allow you to explore what makes a city work well and become a pleasant place to live. The experience will begin with you designing an ‘ideal’ city. Following this introductory activity, you will take part in an online fieldtrip to four cities around the world. You will explore these cities using Google Maps and Street-view, you will be encouraged to watch video clips about each of the cities. You will collect interesting ideas from the cities that they explore, and will create a blog about these ideas. This blog will be password protected and will not be publically available. This topic and these activities are relevant to the Transition Year Geography curriculum and will take place within your timetabled Geography/ Global Issues lessons. The activities will take approximately three weeks (8-9 lessons) to complete. After exploring the four cities online and creating a blog about their experience, you will re-design your original city. Throughout this fieldtrip you will be working as part of a group.

If you agree to take part in this project, this information will be used in the research, stored at Trinity College Dublin and will be anonymous. If the researchers find out about any illegal activities during the study they will have to inform the appropriate authorities (the principal of the school).

During the research, some groups will be interviewed. These interviews will be audio recorded. The reason for this is to help the researcher to analyse the conversation after class. These recordings will be used by the researcher only and deleted as soon as they are no longer needed. These will never be published, broadcast or made available to anyone outside the research team.

This activity will take approximately three weeks (8-9 lessons) to complete.

Do my parents/guardians know about this project?

This study will also be explained to your parents/guardians. You should discuss this with them before you decide to take part.

What will happen to the information that I give during the project

All the information that you give during the project will be kept confidential and made anonymous. It will be stored in a safe way that complies with the Data Protection Act. This act is a law that makes sure that this type of information is kept safely and that the information is not made available to anyone who should not have it.

Do I have to do the project?

Taking part in this study is completely voluntary. If you don't want to take part in the study you do not have to. You can still take part in the activities but your information will not be recorded and will not be used in the research. You are welcome to withdraw from the research at any time for any reason. There is no problem if you choose to take part now but change your mind later, just tell Mr. Rankin who will then remove any of your work/ answers from the research.

Conflict of Interest

Because the researcher is also your teacher there is a conflict of interest. Because the research is taking place in class time, it is very important that the activities are beneficial to you as a Transition Year Geography/ Global issues student and that this research does not stop you from learning in any way. The researcher has made sure that the research topic is relevant to the Transition Year course and will therefore be of benefit to you as you study Geography/ Global Issues.

Publication of Results

The results of this research will be published in a dissertation project that I will write as part of the degree course that I am undertaking (MSc Technology and Learning at Trinity College Dublin). The results may also be published in academic journals or presented at academic conferences in the future.

Important Note

This research involves the use of computers, therefore any student who suffers from epilepsy, or has a family history of epilepsy, will take part at their own risk. If this is the case, please inform Mr. Rankin before the activity begins.

Student Consent Form

Project Title: Enhancing Geographical Thinking in a Post-primary School Setting

I _____ agree to take part in this research project.

DECLARATION:

- I know that my parents/ guardians must also sign a consent form in order for me to take part in this study.
- I have read, or had read to me, a document providing information about this research and this consent form.
- I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.
- I agree that my data is used for scientific purposes and I have no objection that my data is published in scientific publications in a way that does not reveal my identity.
- I understand that if I make illicit activities known, these will be reported to appropriate authorities.
- I understand that I may stop electronic recordings at any time, and that I may at any time, even subsequent to my participation have such recordings destroyed (except in situations such as above).
- I understand that, subject to the constraints above, no recordings will be replayed in any public forum or made available to any audience other than the current researchers/research team.
- I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights.
- I understand that I may refuse to answer any question and that I may withdraw at any time without penalty.
- I understand that my participation is fully anonymous and that no personal details about me will be recorded.
- I understand that if I or anyone in my family has a history of epilepsy then I am proceeding at my own risk.
- I have received a copy of this agreement.
- Data Protection: I agree to Trinity College, University of Dublin storing and using my information from this project for the purposes of research.

Statement of investigator's responsibility: I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

Researcher's Contact Details: Craig Rankin (Student on the MSc Technology and Learning at Trinity College Dublin)

Email: rankinc@highschool.ie/ rankinc@tcd.ie or Ph. 01 4922611

Student Signature: _____

Date: _____

Signature of Project Leader (TCD): _____

Date: _____

Investigator's Signature: _____

Date: _____

Parent/ Guardian Information Sheet

Project Title: Enhancing Geographical Thinking in a Post-primary School Setting

Dear Parent/Guardian

As part of my M.Sc. in Technology and Learning in Trinity College Dublin, I am completing a research project on how the use of technology could enhance students' geographical thinking skills. I wish to invite your child to take part in this research project, which is being conducted by Craig Rankin (your son/ daughter's Geography teacher and student on MSc Technology and Learning in Trinity College Dublin) and supervised by Prof. Richard Millwood at Trinity College Dublin.

The learning experience consists of a series of activities that allow students to explore what makes a city work and a pleasant place to live. The experience will begin with students designing their 'ideal' city. Following this introductory activity, students will take part in an online fieldtrip to four cities around the world. They will explore these cities using Google Maps and Street-view, they will be encouraged to watch video clips about each of the cities. Students will collect interesting ideas from the cities that they explore, and will create a blog about these ideas. This blog will be password protected and will not be publically available. This topic and these activities are relevant to the Transition Year Geography curriculum and will take place within your son/daughter's timetabled Geography lessons. The activities will take approximately three weeks (8-9 lessons) to complete. After exploring the four cities online and creating a blog about their experience, the students will re-design their original cities.

During the research, observation, formal and informal questioning will take place and some sessions will be audio recorded for further analysis. Following the research, students may be interviewed about their experience. All data and video recordings will be anonymised when transcribed. At no point will audio recordings be distributed to anyone other than the research team. These recordings will not be replayed or distributed in any public setting or through any presentation of the research. Please note that the anonymised results may be used for publication or dissemination for academic purposes.

All information that is collected by the researcher will be anonymised and stored in accordance with the Data Protection Act at Trinity College, Dublin. In the unlikely event that information

about illegal activities should emerge during the study, the researchers will follow the school's child protection policy and inform the relevant authorities.

The results of this research will be published in a dissertation project that I will write as part of the degree course that I am undertaking (MSc Technology and Learning at Trinity College Dublin). The results may also be published in academic journals or presented at academic conferences in the future.

Permission for this research to take place at The High School Dublin has been approved by the Principal. However, for the research part of the project, information about your child can only be recorded and used with your permission. This will include tracking their development and learning via observations, audio recordings, surveys and tests.

Participation in the research part of the project is voluntary and you may remove your child from the project at any time, for any reason, without penalty and any information already recorded about your child will not be used, or your child may elect to withdraw from this study. As this research involves the use of computers, children with epilepsy cannot take part in either the learning activity or research study, please inform the researcher if this is the case. If there is a family history of epilepsy your child may take part, but will do so at your own risk.

If you have any questions before, during or after the project, please do not hesitate to contact Craig Rankin at The High School Dublin/ Trinity College: **Email: rankinc@highschool.ie/rankinc@tcd.ie or Ph. 01 4922611.**

Parent/ Guardian Consent Form

Project Title: Enhancing Geographical Thinking in a Post-primary School Setting

I (name of parent/ guardian) consent to
..... (name of child) taking part in this research project.

DECLARATION:

- I have read, or had read to me, a document providing information about this research and this consent form.
- I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.
- I agree that my son/daughter's data is used for scientific purposes and I have no objection to this data being published in scientific publications in a way that does not reveal my son/daughter's identity.
- I understand that the results of this research will be published in a dissertation project as part of the MSc Technology and Learning at Trinity College Dublin and may also be published in academic journals or presented at academic conferences in the future.
- I understand that if any illicit activities are made known, these will be reported to appropriate authorities.
- I understand that I may withdraw my son/daughter from this research at any time and for any reason, and that I may at any time, even subsequent to my participation have any data/ recordings destroyed (except in situations such as above).
- I understand that, subject to the constraints above, no recordings will be replayed in any public forum or made available to any audience other than the current researchers/research team.
- I freely and voluntarily agree to allow my son/daughter to be part of this research study, though without prejudice to my/ their legal and ethical rights.
- I understand that my son/ daughter's participation is fully anonymous and that no personal details about them will be recorded.
- I understand that if my son/daughter or anyone in my family has a history of epilepsy then I am proceeding at my own risk.
- I have received a copy of this agreement.
- I agree to Trinity College, University of Dublin storing of any personal data relating to my child which results from this project. I agree to the processing of such data for any purposes connected with the research project as outlined to me.

Statement of investigator's responsibility: I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

Researcher's Contact Details: Craig Rankin (Student on the MSc Technology and Learning at Trinity College Dublin)

Email: rankinc@highschool.ie/ rankinc@tcd.ie or Ph. 01 4922611

Signature of Project Leader (TCD): _____

Date: _____

Investigator's Signature: _____

Date: _____

Parent/ Guardian Signature: _____

Date: _____

Board of Management/ Principal Information Sheet

Project Title: Enhancing Geographical Thinking in a Post-primary School Setting

To the Principal/ Board of Management,

Re: Proposal Research

As part of my M.Sc. in Technology and Learning in Trinity College Dublin, I am completing a research project on how the use of technology could enhance students' geographical thinking skills. I wish to undertake this research in The High School Dublin. I wish to invite the students in my Transition Year Geography and Global issues classes to take part in this research project, which I am conducting and is being supervised by Prof. Richard Millwood at Trinity College Dublin.

The research experience consists of a series of activities that allow students to explore what makes a city work and a pleasant place to live. The experience will begin with students designing their 'ideal' city. Following this introductory activity, students will take part in an online fieldtrip to four cities around the world. They will explore these cities using Google Maps and Street-view, they will be encouraged to watch video clips about each of the cities. Students will collect interesting ideas from the cities that they explore, and will create a blog about these ideas. This blog will be password protected and will not be publically available. This topic and these activities are relevant to the Transition Year Geography curriculum and will take place within my timetabled Transition Year Geography and Global Issues lessons. The activities will take approximately three weeks (8-9 lessons) to complete. After exploring the four cities online and creating a blog about their experience, the students will re-design their original cities.

During the research, observation, formal and informal questioning will take place and some sessions will be audio recorded for further analysis. Following the research, students may be interviewed about their experience. All data and video recordings will be anonymised when transcribed. At no point will audio recordings be distributed to anyone other than the research team. These recordings will not be replayed or distributed in any public setting or through any presentation of the research. Please note that the anonymised results may be used for publication or dissemination for academic purposes.

All information that is collected by the researcher will be anonymised and stored in accordance with the Data Protection Act at Trinity College, Dublin. In the unlikely event that information about illegal activities should emerge during the study, the researchers will follow the school's child protection policy and inform the relevant authorities (in this case, the principal).

The results of this research will be published in a dissertation project that I will write as part of the degree course that I am undertaking (MSc Technology and Learning at Trinity College Dublin). The results may also be published in academic journals or presented at academic conferences in the future.

Your permission for these learning activities and research to take place in Transition Year Geography lessons at The High School Dublin is requested. All participants will also require their own and parental consent to take part in the research. Participation is voluntary and you may withdraw the school from the project at any time for any reason without penalty and any information already recorded from the school will be removed.

If you have any questions before, during or after the project, please do not hesitate to contact me by email: rankinc@highschool.ie/ rankinc@tcd.ie.

Board of Management/ Principal Consent Form

Project Title: Enhancing Geographical Thinking in a Post-primary School Setting

DECLARATION:

- I have read, or had read to me, a document providing information about this research and this consent form.
- I have had the opportunity to ask questions and all my questions have been answered to my satisfaction and understand the description of the research that is being provided to me.
- I agree that data collected during this research project is used for scientific purposes and I have no objection to this data being published in scientific publications in a way that does not reveal the identity of the students involved.
- I understand that if any illicit activities are made known, these will be reported to appropriate authorities.
- I understand that I may withdraw the school from this research at any time and for any reason, and that I may at any time, even subsequent to my participation have any data/ recordings destroyed (except in situations such as above).
- I understand that, subject to the constraints above, no recordings will be replayed in any public forum or made available to any audience other than the current researchers/research team.
- I freely and voluntarily agree to allow these students to be part of this research study, though without prejudice to my/ their legal and ethical rights.
- I understand that the students' participation is fully anonymous and that no personal details about them will be recorded.
- I have received a copy of this agreement.
- I agree to Trinity College, University of Dublin storing of any personal data relating to my child which results from this project for as long as necessary in accordance with the Data Protection Act. I agree to the processing of such data for any purposes connected with the research project as outlined to me.
- I understand that the results of this research will be published in a dissertation project as part of the MSc Technology and Learning at Trinity College Dublin and may also be published in academic journals or presented at academic conferences in the future.
- The board/ principal has been provided with an information sheet which outlines the activities that the students of TY Geography and Global Issues students will take part in during their lessons, how data will be collected and stored and how it can contact the research team.

Statement of investigator's responsibility: I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent.

Researcher's Contact Details: Craig Rankin (Student on the MSc Technology and Learning at Trinity College Dublin)

Email: rankinc@highschool.ie/ rankinc@tcd.ie or Ph. 01 4922611

Investigator's Signature: _____

Date: _____

Signature of project leader (TCD): _____

Date: _____

Signature of Principal: _____

Date: _____

RE: [Research-ethics] Research Ethics Application 11/16 - Approval

1 message

Bridget Gavin <Bridget.Gavin@scss.tcd.ie>

26 February 2016 at 14:18

Reply-To: Bridget.Gavin@scss.tcd.ie

To: Craig Rankin <rankinc@tcd.ie>

Cc: Ethics TCD <research-ethics@scss.tcd.ie>

Hi Craig

The Research Ethics committee has reviewed and approved your application. You may proceed with this study.

We wish you every success in your research.

Regards

Bridget

Bridget Gavin

School of Physics (Monday - Wednesday, +353 (1) 8962019)

Computer Science and Statistics (Wednesday – Friday, +3535 (0)1 8961445)

Trinity College Dublin

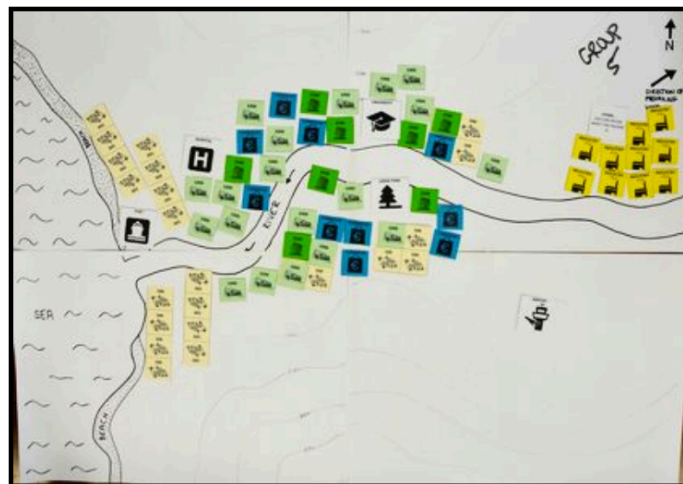
Mobile: +353 86 2162800

[Linked In](#)

Appendix 3 – Adaptive Comparative Judgement Marking Information

Design-A-City Activity Marking

Thank you for agreeing to take part in my research! You will be emailed a link to a website where you will be presented with pairs of work. You will need to decide which piece of work is better. The task the students were set was to design a city that ‘would work well’. They designed their city on a large A1 size base-map using squares that represented various land uses. The students had to decide which type/s of housing density (low, medium or high density) to place in their city. They had to make a city to house 50,000 people. The number of people housed in a square depends on the housing density - A low density housing square houses 500 people, a medium density houses 1000 people and a high density houses 2000 people. The students also had to place 10 units of commercial and 10 units of industrial land use on the map. They then had to decide on the services that they would prioritise in the city. They had to pick 6-8 services out of 16 possible options (on the white squares). The final maps looked like this...



The study that I am undertaking aims to assess students’ higher-order thinking skills. I am looking for city designs that show evidence of geographical thinking skills. A good city design should show evidence of sound geographical reasoning (i.e. the design should show evidence that the students thought about how the city should be formed so as to make it efficient and practical). When assessing the maps, you might look for evidence that the design;

- Avoids urban sprawl - is a relatively compact size
- Has areas of mixed land use and different housing densities throughout the city
- Avoids clustering of all commercial/ residential/ industrial in one area
- Separates incompatible land uses (such as industrial and residential)
- Avoids areas of all high/medium/low density accommodation
- Has logical locations for the services (in white squares on map).

For the purposes of this study, please ignore any transport network that has been drawn onto the map - focus on the location of the various land uses and the overall shape and size of the city.

It is sometimes difficult to say exactly why you think one design is better than another, but go with your gut feeling as this method of marking works well in these circumstances.

Appendix 4 – Example of Open Coding

1. Discuss the type of residential area shown in the picture. Can you identify any pros or cons of this type of development?	CODES										Category Key	Occurrences
spacious area and very clean	Space	Well maintained									Relevant observation/ description (no evident analysis or evaluation)	38
I think this looks like quite a well of residential area. The houses are big and have large gardens. They all have driveways and easy access to the road. I can't see many disadvantages of this area except for that it might be far from the city or urban centre.	Wealthy	Space	Access	Far from city	Peripheral location						Correct application of a geographical term	17
its a clustered residential	Clustered										Correct application of a geographical concept (including supporting explanation)	26
modern residential area.	Modern										Reference to a relevant real-world example (from virtual fielding cities)	0
its very spaced out	Space										Reference to a relevant real-world example (other)	2
this is a spacious residential area. It is connected to a main road which is useful to travel in and out and it connects the area to handover. There is a lot of greenery. It seems like a suburban area which gives you plenty of space and quiet. It is not too fancy or fancy like	Space	Access	Green	Suburban	Peaceful							
Suburban	Suburban											
I think that this residential area has been planned efficiently, with each front and back garden of a similar size. I think that the roads and footpaths have been constructed properly and that it appears to be well maintained. Although living the organisation of this residential area I think that it is perfect for the type of people that live there. It is not too fancy or fancy like	Planned	Space	well maintained	Monotonous								
big housing estate	Planned											
its an estate with a front and back garden	Space											
linear	Linear											
Linear: the pros would be that the people who live there would have a lot of neighbors. The cons would be that the gardens are very small because the houses are so close together.	Linear	Social										
Linear settlement one pro is that there is no overcrowding as the houses are spread out evenly.	Linear	Space										
Pros: Space for large detached houses and big gardens, cheap land, looks nice and nice atmosphere for people living there. Cons: Far from city centre.	Space	Green	Value	Social	Peripheral location							
It is connected to a main road meaning that there is good transport links potentially, but it does not look like there are a lot of facilities nearby.	Access	lack of facilities										
pros each individual has a good amount of living space	Space											
pros are that there is a main road and the cons are that it is that there is no nearby shops in the area	Access	lack of facilities										
this type of development allows for lots of living space and plenty of access for transport, however it also leads to urban sprawl and it does not appear to have any transport services e.g. bus	Space	Access	Urban Sprawl	lack of facilities								
pros: Cons - 1.planned infrastructure 2.Large living space and garden	Space	Infrastructure	space	suburban	USA							
suburban area it is not very close to any facilities it looks like a safe area. It looks like its in the US.	Safe	lack of facilities	peripheral local									
The residential area looks very peaceful and family friendly. Pros of this type of residential area could include size and amount of houses and how they are all so close together and built social means as well as driveways which make the road very accessible. Cons of this area could include how linear the structures are meaning the people in the houses may lack privacy.	Social	Access	Linear	Privacy								
This residential area would be good for families - the houses are big and have big gardens and are in a safe area where there isn't a lot of traffic. The cons would be that there mightn't be as much jobs unless you were to travel more inward into the city.	Family - friendly	Space	Quiet	Peripheral local	long commutes							
It is a nucleated residential area. If I was going to live there I would have to think about if the neighbours are nice, where the sun is facing, how big my gardens going to be. If there is a low crime activity rate and if traffic build up is a problem.	Nucleated	Social	Safe	Aspect	Traffic							
It is built along a road which makes it a good place to settle down because you will be easily able to access a lot of places. There would be a lot of neighbours for the residents here which would most likely attract families to the area. The cons of living here are there would be a lot of noise pollution because it had to sleep and the roads may also be a danger to young children who are playing outside.	Access	Social	Family-friendly	pollution	danger							
I think it is linear settlement. The advantages of this settlement are you are close to other people in case of emergencies but you still have space.	Linear	Safety	Space									
It is an estate which has a low density so there are big houses and big gardens pros: lots of space for houses Cons: long commutes to work	Low Density	Peripheral local	long commutes									
Suburban estate, maybe in America. Large back gardens, less traffic and lots of neighbours who have children. Probably quite far from jobs so more money is put into commuting.	Space	Less traffic	long commutes	USA								
In this type of development you can see that there is a good back garden in every house in terms of space. This type of development can become quite clustered and this can lead to disturbance between neighbours	Space	noise										
Pros: Large amount of space for people in houses, gardens, etc. Cons: Takes up a large amount of land, often situated far away from city centers, long commutes to work/school not uncommon.	Space	urban sprawl	long commutes									

Appendix 5 – Open Coding Frequencies

Question 1.1	Code	Pre	Post
Relevant observation/ description (no evident analysis or evaluation)	RO	12	21
Correct application of a geographical term	GT	3	5
Correct application of a geographical concept (including supporting explanation)	GC	3	12
Reference to a relevant real-world example (from VFT cities)	EF	0	12
Reference to a relevant real-world example (other)	EO	2	3
	Total Count	20	53
	Word count	821	1139

Question 1.4	Code	Pre	Post
Relevant observation/ description (no evident analysis or evaluation)	RO	11	17
Correct application of a geographical term/ concept (without explanation/ development)	GT	8	16
Correct application of a geographical term/ concept (with supporting explanation)	GC	9	14
Reference to a relevant real-world example (from VFT cities)	EF	0	7
Reference to a relevant real-world example (other)	EO	1	1
	Total Count	29	55
	Word count	847	1364

Question 2.1	Code	Pre	Post
Relevant observation/ description (no evident analysis or evaluation)	RO	14	17
Correct application of a geographical term/ concept (without explanation/ development)	GT	3	2
Correct application of a geographical term/ concept (with supporting explanation)	GC	5	14
Reference to a relevant real-world example (from VFT cities)	EF	0	2
Reference to a relevant real-world example (other)	EO	0	0
	Total Count	22	35
	Word count	1025	1139

Question 2.4	Code	Pre	Post
Relevant observation/ description (no evident analysis or evaluation)	RO	16	20
Correct application of a geographical term/ concept (without explanation/ development)	GT	1	5
Correct application of a geographical term/ concept (with supporting explanation)	GC	13	18
Reference to a relevant real-world example (from VFT cities)	EF	0	2
Reference to a relevant real-world example (other)	EO	0	1
	Total Count	30	46
	Word count	1104	1096