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Developing Health and Safety Guidance

for

Geodetic Engineering Surveyors

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Ph.D. Mechanical (Industrial) Engineering

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Developing Health and Safety Guidance

for

Geodetic Engineering Surveyors

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Submitted for the qualification of Doctor of Philosophy in

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Discipline of Mechanical Engineering

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'But, when a boundary case arises, it is entrusted to the land-surveyor, to put an end to shameless quarrels. Of necessity, he is the judge of his own art; his law-court is abandoned fields; you might think him a man possessed, as you see him walking the winding paths. For he seeks his evidence among rough woods and thickets; he does not walk as all men do; his route and his reading are one. He points out what he tells you; he proves what he has learnt; his footsteps clarify the rights of disputants; and, like a vast river, he takes land from some, and gives fields to others.'

Flavius Magnus Aurelius Cassiodorus, *Variae*

Roman statesman. *fl*. sixth century AD

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ABSTRACT

Geodetic engineering surveyors are integral to the entire construction process and work in a sector that is considered occupationally hazardous. The aim of this research was to determine the extent of health and safety education that students of this discipline receive while attending higher-level educational programmes in the Republic of Ireland and to propose remedying actions if deficiencies were found.

Historical aspects of surveying were chartered and the standard educational experience of surveyors profiled with respect to health and safety. The profession's training and governing legislation was also examined – with the latter highlighting a clear regulatory exclusion of the profession's activities. From there, a case study demonstrated the hazards of the occupation. This in turn led to a questionnaire being administered to academic directors and lecturers of the discipline (n = 45) from Irish universities and institutes of technology. Results revealed that the majority of geodetic engineering surveying (GES) programmes do contain some tuition in health and safety, albeit by a narrow margin (+5%). This tuition is provided as a component of a module in 73% of cases. When the subject is offered in a standalone capacity, an average of five European Credit Transfer Accumulation System (ECTS) credits are assigned. In relation to pedagogical approach, 75% of respondents stated that health and safety tuition offered is not specifically designed for GES practitioners.

The research concludes that in the Republic of Ireland, higher-level education in health and safety varies greatly on GES programmes. In the majority of cases it is of short duration and very much generic. To remedy the situation, an electronic Safe System of Work Plan (SSWP) application was proposed that is of use in both an academic and professional environment.

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LIST OF ABBREVIATIONS AND ACRONYMS

AGA	Advanced Geodetic Applications
ALISON	Advance Learning Interactive Systems Online
CLEG	Council of European Geodetic Surveyors
CPS	Crown Prosecution Service (UK)
CSCS	Construction Skills Certification Scheme
CSO	Central Statistics Office (IRL)
DETI	Department of Enterprise, Trade and Innovation (IRL)
DIT	Dublin Institute of Technology
ECTS	European Credit Transfer System
EDM	Electronic Distance Measurement
EEGECS	European Education in Geodetic Engineering, Cartography and Surveying
ESB	Electricity Supply Board (IRL)
EU-OSHA	European Agency for Safety and Health at Work
GES	Geodetic Engineering Surveying
GIS	Geographical Information Systems
GLONASS	Global Orbiting Navigation Satellite System
GPS	Global Positioning Satellite Technology
HSA	Health and Safety Authority (IRL)
HSE	Health and Safety Executive (UK)
IIS	Irish Institution of Surveyors
IOSH	Institution of Occupational Safety and Health
IRLOGI	Irish Organisation for Geographic Information

ISSP&RS	Irish Society of Surveying Photogrammetry and Remote Sensing
LASER	Learning About Safety by Experiencing Risk
LCA	Leaving Certificate Applied
LCVP	Leaving Certification Vocational Programme
LMA	Land Made Available
NAVSTAR	Navigation Satellite Timing and Range
NCCA	National Council for Curriculum and Assessment
NCTE	National Centre for Technology in Education
PLC	Post Leaving Certificate
PPE	Personal Protective Equipment
RDD	Random Digit Dialling
RF	Radio Frequency Waves
RoSPA	Royal Society for the Prevention of Accidents
RSA	Road Safety Authority
RSI	Repetitive Strain Injury
S.I. No.	Statutory Instrument Number
SCS	Society of Chartered Surveyors
SDS	Safety Data Sheet
SEDB	Surveying Education Database
SPHE	Social, Personal and Health Education
SSL	Secure Sockets Layer
SSWP	Safe System of Work Plan
STA	Sequential Task Analysis
TLIG	Third Level Initiative Group

DECLARATION OF ORIGINALITY

I hereby declare that I have read and understood the University Code of Practice on Plagiarism and confirm that the content of this thesis is original in all aspects, apart from segments that have been clearly referenced using the appropriate format.

Oisín Patrick Kearns

October 2018

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Above all, I would like to profoundly thank Dr Martina Kelly for giving me the opportunity to carry out this research and the good counsel to ensure it was completed. Rather than try to convey my gratitude in awkward prose, I hope the following presentation in some way reflects the passion you have instilled in me to question the known knowns — that is to say the things I know I know. The known unknowns — that is to say the things I know I don't know. And the unknown unknowns — that is to say the things I do not know I don't know.

Let the Plain English Society cower…

CHAPTER ONE

Introduction

1.1 Geodetic Engineering Surveyors

A geodetic engineering surveyor is an individual who surveys land with a view to positioning and enabling aspects of civil and building construction. Colloquially they are often known and described as *land surveyors*—a profession associated with determining the locations of '*natural and man-made features on the earth's surface*' (Bannister, Raymond and Baker, 1998). However, since the publication of the *Profile Report* by Stannard (1996), the Comité de Liaison des Géomètres Européen[1] has determined that the title of geodetic surveyor shall be used to describe surveyors involved in any of the following disciplines:

- Land Surveying—surveying the physical features of and on the earth.
- Hydrography—surveying aspects of the earth's surface covered by water.
- Photogrammetry and Remote Sensing—surveying through the use of photographic and digital images.
- Cadastral and Boundary Surveying—surveying in order to determine and interpret boundaries and demarcations.
- Land and Geographical Information Systems—surveying land and geographical information using computer systems.
- Minerals and Mining Surveying—surveying for the discovery of minerals and related works.
- Engineering Surveying—surveying that enables and facilitates the application of civil or other engineering projects.
- Cartography—surveying that facilitates the creation of maps and charts.

[1] The Council of European Geodetic Surveyors (CLGE) is a professional body mandated to promote the interests of the geodetic surveying profession in Europe. Established in 1972, CLGE is Europe's largest body for this occupation and currently represents approximately 20,000 surveyors across Member States (CLGE, 2011).

Given that the crux of this investigation is focused on surveyors in the construction sector, the most apt title for use in this thesis is therefore a *geodetic engineering surveyor* (GES). However, since its etymology only dates from the mid-1990s, the term *land surveyor* has also been used in discussions relating to aspects of historical surveying.

1.2 Rationale

The rationale for this thesis stems from geodetic engineering surveyors' role in the construction industry and the extent of educational resources at their disposal.

Often the first individuals to arrive on site, surveyors are tasked with determining the location of services and establishing site borders from land made available (LMA). During the main construction phase, they are usually based on site, engaged in setting out the proposed routes of development and infrastructure. In many cases they are also the last profession to leave a site, as their responsibility can include surveying to facilitate the creation of as-built drawings at the end of a project. Thus, it is fair to categorise the surveyor as someone who is integral to the entire construction process.

As a result, surveyors must operate in a sector that has consistently featured in the list of the most dangerous occupational activities in the Republic of Ireland,[2] one that exposes them to a plethora of hazards. However, the ramifications of working in this sector reach further for these professionals, as unlike other construction-based occupations, ostensibly the health and safety body of research does not specifically address this cohort.

[2] Using the Nomenclature Générale des Activités Economiques dans l'Union Éuropéenne (NACE) Classification Scheme [revision 1 and 2], the Health and Safety Authority has recorded 207 construction-related fatalities in the Republic of Ireland since 2002. Figures for 2002–2007 represent the highest out of all economic sectors, and for 2008–2015 the second highest with the exception of the year 2011. This year to date (September 2018) has seen an additional 5 fatalities in the sector.

Such an assertion can be made after an exploratory search into what information the typical professional organisations provide (See Table 1.1 below). Due to the dearth of relevant health and safety literature for these professionals, they must rely on their formal education from higher-level study.[3] However, to date, the body of research has not revealed the extent of such tuition. For this reason, the ensuing research project can be rationalised, as it has the potential to deliver an insight into the current state of provision relating to the health and safety education of geodetic engineering surveyors.

Table 1.1 Health and safety information available from professional organisations specifically for geodetic engineering surveyors

ORGANISATION	INFORMATION AVAILABLE
Health and Safety Authority	No information
Irish Institution of Surveyors	No information
Society of Chartered Surveyors Ireland	No information
Engineers Ireland	No information
National Irish Safety Organisation	No information
Chartered Institution of Building Services Engineers (UK)	No information
Health and Safety Executive (NI)	No information
Health and Safety Executive (UK)	No information
Institution of Occupational Safety and Health (UK)	No information
The Royal Society for the Prevention of Accidents (UK)	No information
Royal Institution of Chartered Surveyors (UK)	Fleeting reference to the subject
British Safety Council	No information
Institution of Highway Engineers (UK)	No information
Institution of Civil Engineers (IRL)	No information
International Federation of Surveyors	No information
Council of European Geodetic Surveyors	No information

[3] The author is aware that opportunities for learning health and safety are present in an occupational environment, either through emulation or structured tuition; however, such opportunities are not universal and are hence unquantifiable in the context of this research.

1.3 Research Hypothesis

The hypothesis of this research is that a significant amount of occupational health and safety is not taught on the majority of higher-level geodetic surveying courses. This hypothesis will be subjected to systematic empirical testing with emphasis placed on demonstrating it is *false*. Such a statement may sound contradictory to the desired impartiality of good research, but it accords with the findings of Burns (2000), who maintains that one should not look for confirming examples of conjectures—as such confirmations are often too easy to find—but instead submit hypotheses to the most rigorous tests that can be found. This approach is also in line with earlier writings of Popper (1902–2004), who in his *Logic of Scientific Discovery* proposed the doctrine of *falsifiability*: essentially the belief that all hypotheses should be submitted to methodical testing to show they are wrong (Popper, 2002). By adapting this position, scope has been left to support or reject the hypothesis in a scientific manner.

1.4 Research Aim and Objectives

The aim of this thesis is to conduct a descriptive cross-sectional enquiry into the health and safety education of geodetic engineering surveyors in the Republic of Ireland. In order to actualise this aim, the following research objectives have been identified and will be delivered through a methodology-coherent approach:

I. Describe the etymology, purpose and importance of a geodetic engineering surveyor in the construction process.

II. Document existing educational provisions for surveyors through a detailed literature review.

III. Illustrate the typical hazards a geodetic engineering surveyor faces in the construction environment.

IV. Discuss the relationship between health and safety legislation and the geodetic engineering surveyor.

V. Conduct a self-administered survey of course directors and lecturers from universities and institutes of technology in the Republic of Ireland who oversee courses that contain tuition in geodetic engineering surveying.

VI. If necessary, recommend suitable means of rectifying identified deficiencies.

1.5 Research Scope

Attempts were made to keep the parameters of investigation as broad as possible; however, some aspects of research were deemed to be outside the study's scope. Initially, it was proposed to conduct additional research into Irish Post Leaving Certificate (PLC) programmes, but this was not feasible due to the complexity of the PLC system.

Although numerous educational programmes in geodetic surveying operate internationally, this study is focused on comprehensively examining courses in the Republic of Ireland. The research's scope is also limited to addressing the opinions of course directors and lecturers and does not attempt to gain the views of any other parties.

1.6 Thesis Contribution to Knowledge

I. Following empirical field-based investigation in the form of a case study, the considerable hazards of the GES profession were identified and expounded. No similar investigations existed in the body of published literature; therefore, the case study is of value and assistance to external organisations by allowing them to look at the represented hazards and evaluate if comparable dangers exist in their own organisations. The case study also provided scientific material for development of a safety educational aid.

II. An examination of the standard of health and safety tuition on higher-level GES programmes in the Republic of Ireland revealed considerable variation in the teaching of the discipline, and in 75% of cases. no information being specifically offered to geodetic engineering surveyors.

III. An electronic Safe System of Work Plan (SSWP) was proposed that would be of use in both an academic setting and the GES professional environment.

CHAPTER TWO

Surveying from a Historical Perspective

2.1 Land Surveying from a Historical Perspective

The profession of land surveying has been an intrinsic part of civilisation since antiquity. The earliest literary evidence of this can be found in the fifth century BC, when Herodotus documented in the *Histories*[4] how Egyptians who had lost a proportion of their land due to the flooding of the Nile were entitled to ask the king [Sesostris] to send inspectors to measure the quantity of their remaining holdings so that the payment of future taxes would be proportionate. Herodotus accredits these undertakings by the Egyptians as the genesis of geometry [earth-measurement].

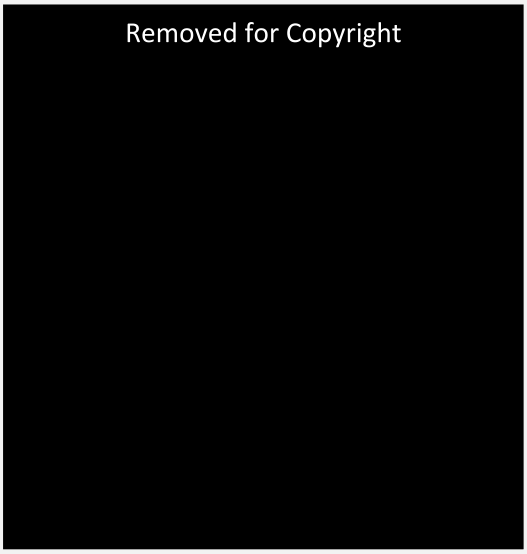

Fig. 1.1 Tomb of Djeserkeresonb, ***courtesy of the Osirisnet Project***

According to research by Salmon (2003), much of this early geometry was done with instrumentation such as lengths of cord, measuring rods and plumb-lines, as illustrated by Figure 1.1 that shows a photograph from the Tomb of Djeserkeresonb (c.1386 BC) depicting a surveyor and his assistants taking land measurements using the aforementioned equipment.

Be that as it may, Isler (2001) reminds us that despite the earliest annals on the subject originating from the fifth century BC, proof of Egypt’s surveying efforts from a much earlier period can still be seen today in the symmetry of the Pyramids—some of which were constructed as early as 2630 BC.[5]

[4] The *Histories* of Herodotus is generally accepted as one of the first works of historical literature in Western Culture. This citation comes from Part 109 of Volume II, *Euterpe*, from the translated text of Rawlinson (1996).
[5] Pyramid of Djoser in Saqqara (*National Geographic*, 2011).

Even though the complexity of the early Pyramids is unquestionable, it is legitimate to speculate that the surveying instrumentation and techniques of the early Egyptians were very primitive. History accords to this belief, and it is the Greeks who are accredited with being the main protagonists in the promotion of the discipline.[6] This occurred largely as a result of the early touring Grecian scholars who recognised the potential to learn geometrical techniques from the Egyptians[7] and through inherited practices following the invasion of pharaonic Egypt by the Greeks in 332 BC.

Noted for their ability for abstract thought and their pioneering historical contribution, it was the Greeks who invented the dioptra—a sighting tube that when in vertical mode calculated heights and levels, and when in horizontal mode measured angles.

Although historians have not been able to accurately ascertain when the dioptra was invented or by whom, it became the standard surveying instrument of choice for the Greeks.[8] No examples of original dioptras survive today, and valid attempts at reconstruction have been limited. However, Figure 1.2 overleaf does illustrate one such effort constructed by Lewis (2001).

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[6] This overview deals exclusively with the activities of the early Egyptian, Greek and Roman surveyors; however, other ancient culture groups such as the Babylonians and Chinese also took formative steps in the discipline. For discussion relating to these, the early text of *Surveying Instruments: Their History* by E.R. Kiely (1979) provides a clear synopsis.

[7] Karamanides (2006) documents how Pythagoras travelled to Egypt in the 6th century BC and for a period of twenty-two years primarily studied geometry. Allman (2005) reports similar exploits by Thales. These Greek scholars returned to their native country with a primitive understanding of early geometric rules, and according to Brock (2004) are ascribed with giving Greece its first introduction to surveying.

[8] The dioptra is thought to have been developed around 200 BC. Hero of Alexandria, although not the original inventor, wrote a treatise on the device that still survives today. In this somewhat arduous account he outlines the working of the instrument and gives a description of a version he redesigned. He does not, however, detail the work of his predecessors.

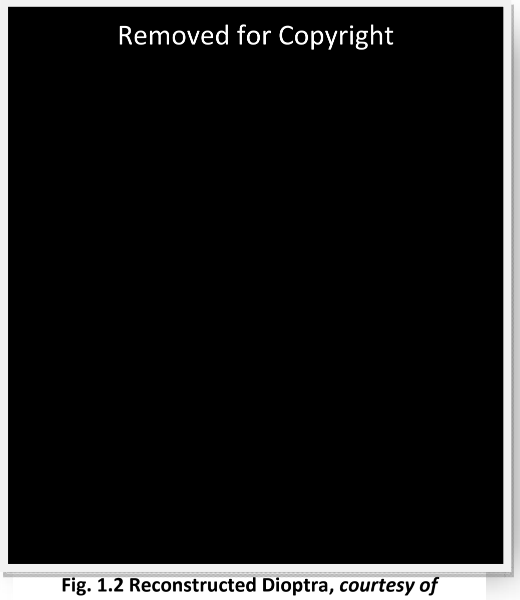

Fig. 1.2 Reconstructed Dioptra, *courtesy of Cambridge University Press*

Despite the dioptra's prominence, doubt exists over its accuracy. Given that the Greeks primarily concentrated on architecture and not civil construction, surveying-related mistakes from such equipment may have been tolerated, as results were often aesthetic and not detrimental to a project's success. This would not have been the case in Roman society, as they needed precision for their exploits in colonial settlement, land taxation, road construction, aqueducts and military proliferation. For this reason the dioptra was not exported to Rome, but many of the Grecian concepts and hypotheses regarding geometry were. These ideas were then adapted into more complex surveying instrumentation, which in turn led to the increased professionalisation of the surveying discipline.

Known as agrimensors, the Roman land surveyors were a prolific profession.[9] At their disposal was a range of equipment and instrumentation for levelling that included the chorobates—essentially a twenty-foot builder's level—and the libella, an extensively used A-frame level with a plumb line. However, it is the groma that history attributes as being the most notable surveying instrument of the agrimensors.[10]

[9] The *Corpus Agrimensorum* (c. 4th century AD) is the main treatise on land surveying from Roman times. Compiled by multiple authors, the corpus affirms the importance of the profession and includes contributions from predominant Roman figures such as Sextus Julius Frontinus, Governor of Britain. Although undoubtedly a demanding text to follow, for a verbatim translation see Campbell (2000).

[10] Lewis (2001) speaks of the agrimensors becoming ultimately known as *gromatici* due to their widespread use of the groma.

Although outdated in some respects, Deumlich's (1982) portrayal of the groma as a '*cross fastened eccentrically on a wooden staff with plumb bobs*' serves as the best description of this instrument. Designed to set out straight lines and right angles,[11] it was used predominantly in road construction and the codification of centuriation.[12] Historical literature does not claim to know when the instrument was first used or by whom, but it does point to great longevity of use. Evidence of this can be found in the writings of Rossi, Russo and Russo (2009) that suggest how it may have been used as early as the fourth century BC, and also in the publishing of Adkins and Adkins (2004) that indicate how parts of a groma were found in the 1912 reclamation of the ruins of Pompeii that date from AD 79. The findings at Pompeii are of further significance, as ten years later M. Della Corte created a reproduction schematic of what the groma actually looked like (Della Corte, 1922 cited in Lewis, 2001, p. 128) that is widely accepted as the representative version.[13] From this diagram, models of the instrument were produced, an example of which can be seen in Figure 1.3.

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Fig. 1.3 Reconstructed Groma, *courtesy of Science Museum London*

Following the demise of Roman rule to the barbarian armies, many practices in the art and science of surveying were lost in the prevailing intellectual darkness. This was compounded by an ecclesiastical influence that restricted the empirical study of the

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[11] For a more detailed overview of the instrument in non-specialist terms, see H. McCague, *Learning from the Roman Land Surveyors: A Mathematical Field Exercise*, in Shell-Gellasch (2007).
[12] The division, demarcation and mapping of lands following colonisation.
[13] Relatively recent research by Schiöler (1994) disputes the representation, although it must be said that the issue has been debated over time with not much definitive conclusion (Lewis, 2001; Ferrar, 2011).

sciences for many centuries. However, Glick, Livesey and Wallis (2005) document that this hiatus eased somewhat in the ninth and tenth centuries with the discovery and transcription of the Roman surveying treatises. As a result, by the late Middle Ages the measurement of lands for fiscal taxation had become commonplace, leading to a need once again for surveyors.

Lilley (1998) suggests that little is known of these medieval surveyors, although Bagrow and Skelton (2009) propose that their equipment was limited to very basic instrumentation such as measuring rods. However, more sophisticated instrumentation was also developed in Europe during this period, as Rana and Sharma (2006) claim that by the eleventh century the astrolabe—a device used to locate the position of the sun, moon, stars and planets—had been introduced via Islamic Spain. Although customarily associated with astrological use, Lawton, Copeland and Scase (2003) document how it could also be used for terrestrial land surveying as it was often equipped with an alidade (sighting device), thus marking a return to similar scientific methods of surveying as employed by the antecedent Greeks and Romans.

From this point on, the discipline flourished. In relation to education, Lettice Thrupp (1988) documents how surveying methods were taught as part of the *Quadrivium*[14] in medieval universities by the twelfth century, while the historical early writing and illustrations of Bertrand Boysset (1355–1415) convey that the activity of surveying had become a recognised profession by the fourteenth century (MS 327).

[14] The four subjects of study comprising arithmetic, geometry, astronomy and music, taught to students following completion of the *trivium* subjects of grammar, rhetoric and logic.

Such developments were undoubtedly aided by technological advances that laid out a clear trajectory for advancement in the field, such as the compass in c. thirteenth century. However, Roy (2004) credits the rise of the fifteenth-century early Renaissance and the subsequent revival in exploration and trade as the catalyst for renewed interest in surveying, as such voyages of discovery resulted in the delineation of territories and significant cartography developments that relied on the services of surveyors. Nevertheless, this epoch did see major technological advancements, as by the mid-sixteenth century the English mathematician Leonard Digges documented in chapters 27, 28 and 29 of his book *Pantometria*[15] a device called a *theodelitus*. His work, annotated and published posthumously by his son Thomas, is widely accredited as the first literary account and early description of the modern theodolite—a device used by surveyors primarily to measure horizontal angles between two points and the angle of elevation. Although not constructed by Digges, the earliest known theodolite still in existence is dated 1586 and accredited to Humphrey Cole; an illustration can be seen in Figure 1.4.

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Fig. 1.4 Cole's Theodolite, ***courtesy of the Museum of the History of Science, Oxford***

The seventeenth century also saw another mathematician, Edmund Gunter, develop a device, aptly known as a Gunter Chain (see Figure 1.5 page 16), for measuring the length of land. Made of iron, this 100-link chain measured 66 feet in length and was equipped with a brass teller on every tenth link to denote position. The value of the

[15] For the work's full title see Pantometria (1571) in the end-of-text reference list.

chain from a demarcation perspective could be found in the fact that 10 sq. chains equated to one acre.[16] In relation to longevity of use, Gibson (1832), in his nineteenth-century book on the theory and practice of surveying, lists an '*enumeration of instruments useful to a surveyor*' that includes an assortment of measuring chains, while Estopinal (2009) remarks that Gunter's chain remained at the forefront of horizontal land measurement up until the twentieth century. Those that carried the chain were appropriately called *chainmen,* a designation that is still used today to denote a surveyor's assistant or technician. Although the chains were relatively easy to use, the job required a tremendous amount of physical labour due to their heavy, cumbersome nature.[17] This may have been a factor in bringing about the need for more advanced methods of surveying in the latter part of the twentieth century, but more probable was the advent of world war and the subsequent post-war reconstruction, coupled with the continuous shift from an agrarian to a more industrialised society.

[16] See De Capo Press's (New York, 1971) reprint of Edmund Gunter's *Use of the Sector, Crosse-staffe, and Other Instruments* (1624) for additional details on the original design concept.
[17] In December 2009, Channel 4 (UK) aired a five-part televised programme entitled *The Worst Jobs in History.* One episode portrayed the work of early chainmen and stated that the occupation was suited to the programme's title due to the amount of manual labour required.

Fig. 1.5 Gunter's Chain equipped with brass tellers, *courtesy of Dr Patrick Brown*

The 1950s saw the introduction of Bergstrand's electronic distance measurement (EDM) instrument—a device that works on the principle of the time taken for a light beam to travel from one instrument to a reflector and back, thus allowing the calculation of distance.[18] First produced in 1953 by the Swedish company Advanced Geodetic Applications (AGA) in the form of the Geodimeter *System Bergstrand Type NASM-1* (see Figure 1.6),[19] the instrument revolutionised the laborious task of distance measurement and all but made the chain and other aspects of taping-by-hand redundant, thereby allowing an increase in output for the surveying profession.

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Fig. 1.6 Early Geodimeter, ***courtesy of the University of New South Wales***

Other reincarnations of the EDM in the late 1950s and 1960s respectively would see the introduction of microwaves and laser beams used to measure distance. The 1960s also saw the Carl Zeiss Corporation redesign the theodolite into an electronic version that in turn aided production.[20] However, in 1978 the surveying profession would see a seismic change with the introduction of the Hewlett-Packard 3820, the world's first total station instrument (see Figure 1.7 overleaf). The moniker *total station* was given to this instrument as it was in essence a marriage of the electronic theodolite and the EDM into one device. As a result, the total station

[18] For an early, more thorough description of the instrument, see: 'The Geodimeter: An Instrument for the Accurate Measurement of Distances by High Frequency Light Variations', *Survey Review* Vol. 11 No. 85. July (1952), Maney Publishing.
[19] This picture illustrates a slightly later version of the Geodimeter—model: NASM-2A—from 1959, which was the first commercially available model.
[20] In 1968, the Zeiss Corporation released the *Zeiss Reg Elta 14.* Although the device was essentially an electric theodolite, it was sold under the synonym of an electronic tacheometer.

enabled the measurement of horizontal and vertical angles as well as horizontal and vertical distance through the use of a central processor and an electronic recording capability. The instrument consequently became the primary tool for surveyors in the subsequent decades. However, when discussing land surveying from a historical perspective, the one other major development in the twentieth century that enabled a quantum leap forward in the manner in which surveys could be conducted was the introduction of global positioning satellite technology (GPS).

Developed and deployed by the United States Department of Defence in 1978, NAVSTAR (Navigation Satellite Timing and Range) was the world's first GPS system.[21] It works by allowing a satellite positioning receiver to capture signal transmitting from a constellation of four or more satellites orbiting over 20,000 km from the earth's surface, which in turn enables the determination of the receiver's coordinates. In 1983, the GPS ceased being available for sole military use[22] and was made accessible to the civilian population, albeit with purposely degraded signal accuracy for security purposes. These restrictions remained in place until the year 2000, severely hampering developments in the surveying industry. However, upon their removal the industry flourished; new instrumentation incorporating the GPS technology expedited the survey process as

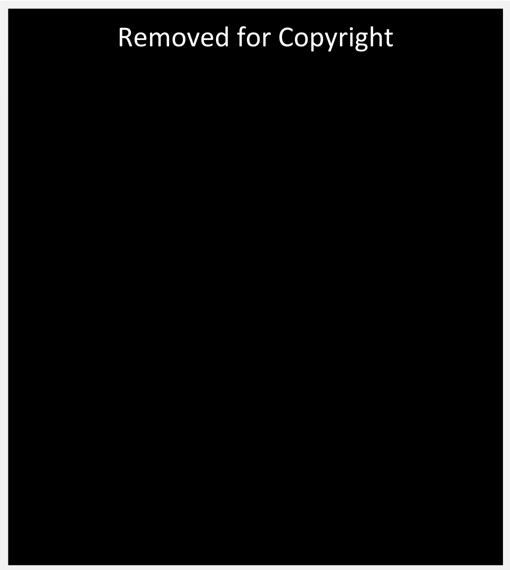

Fig. 1.7 Hewlett-Packard 3820 ***courtesy of Professional Land Surveyor Magazine***

[21] It took until the year 1995 to become fully operational.

[22] U.S. President Ronald Reagan declassified the GPS system in response to the shooting down of Korean Airplane KAL 007 over Soviet territory after it accidently strayed off course during a flight from New York to Seoul on 1 September 1983.

clear lines of sight were for the first time not needed. Pinpointing of coordinates to within millimetres became commonplace as the technology advanced. The cost of GPS-enabled instrumentation decreased, making it accessible to wider markets. In addition, as the technology was novel, training opportunities were numerous, leading to many new surveyors joining the profession. Parallel with these developments was the advancement of GPS systems that were compatible with geographical information systems (GIS).[23]

Having chartered the land surveying profession from a historical perspective, an overview of a somewhat complex occupation has been given in non-specialist terms. Although it is not within the scope of this thesis to discuss in detail all the advancements that culminated in the twenty-first century surveyor, the foregoing synopsis of the most pertinent developments serves to highlight how the skills and services of land surveyors have continuously been needed throughout the world since times of antiquity.

Ireland has not been an exception to this fact. The earliest known cartography efforts of this country date back to the times of Claudius Ptolemy [of Alexandria] in AD 150. The latter British colonial incursion was also underpinned by strong surveying practices in order to facilitate land division and taxation (albeit not always popular, as evident by the beheading of the English surveyor and cartographer Richard Bartlett, in 1604, by the Irish). Historically, surveyors' remit in this country has also extended past their customary role of simply measuring land. As Edney (1997) quite rightly points out, early ordinance survey maps were often accompanied by surveyors' memoirs. These memoirs, according to Ó Cadhla (2007),

[23] GIS is a process of organising spatial data in order to exhibit and analyse its value using computerised technology. It allows strata of collected data from a survey to be superimposed onto a digital map and interrelationships assessed.

show that surveyors, in addition to their usual responsibilities, were also major contributors in recording the ethnography and anthropology of the Irish people on everything from diseases to folktales.

In relation to Irish surveyors' education, by 1967, Dublin Institute of Technology (DIT) was offering a four-year honours degree-level course in the discipline, while other institutes of technology and universities were offering numerous programmes in civil engineering, construction studies and various other subjects that amalgamated aspects of surveying.

By 1998, there were an estimated 500–600 geodetic surveyors working in Ireland (IGSLG, 1998) and a host of professional bodies in operation, such as the Irish Institution of Surveyors (IIS), the Society of Chartered Surveyors (SCS), the Irish Society of Surveying Photogrammetry and Remote Sensing (ISSP&RS) and the Irish Organisation for Geographic Information (IRLOGI).

The opening decade of the twenty-first century saw an auspicious rise in Irish surveying activities, as the building boom took hold. Prendergast (2004), reporting on the results of an investigation into the Irish surveying sector, suggested the market turnover was in excess of €68 million per annum.[24]

Although the surveying sector has undoubtedly suffered from contraction in the recent global economic crisis, constant development and investment in technology is keeping the industry viable as economy recovery takes hold. The most prevalent is the continued propagation of satellite positioning systems in the form of the Russian military navigation system, GLONASS (Global Orbiting Navigation Satellite System) and the EU Transport Committee/European Space Agency satellite

[24] Research by Schuster et al. (2003) a year earlier concluded that the surveying professions' contribution to the Gross European Product was in excess of €24 billion per annum. The same report indicated that there were more than 536,000 people employed in the industry across the European member states.

system, Galileo: the world's first civilian-operated satellite navigation system.[25] All of this has led to advancements in surveying instrumentation that has resulted in the potential for faster, more accurate surveys.

In conclusion, the word *surveyor* is derived from the French word *surveoir* meaning *to oversee*. Such a meaning typifies the work of this profession, as it is they who have helped oversee the development of the world around us for the last five millennia. It is an ancient profession that has embraced change throughout the ages, and as a result looks set to retain a significant role in all subsequent societal development. But what about present day educational programmes offered to those seeking entry to the profession? Do they attribute the necessary skills and training graduate geodetic surveyors need to manage occupational health and safety in today's dynamic workplaces?

Before this can be answered it may be useful to give an overview of the current educational provisions that exist for this profession. Chapter Three explores this theme.

[25] Collectively all three systems (GPS, GLONASS and Galileo) are becoming known as GNSS: the Global Navigation Satellite System.

CHAPTER THREE

The Education of Geodetic Engineering Surveyors

3.1 Introduction

The education of geodetic engineering surveyors is a somewhat complex matter. This chapter aims to highlight the current situation in the Republic of Ireland and attempts to give the reader an insight into what levels of tutelage a surveyor can expect to obtain while studying the discipline. For comparative purposes, preceding and contemporary international practices in this field shall also be documented.

Overall, the body of research indicates that surveying schools are among the first established in the discipline of engineering in every country (FIG, 2010). Such programmes are relatively small, and from a monetary perspective can be costly to operate (Markus, 2004). Studies also suggest (Lisec et al., 2009) that continuous changes in technology are influencing what is taught on these programmes, and as a result, educational providers are struggling to create an equilibrium between teaching new material and at the same time teaching the required '*traditional services*' to students. Specifically in the discipline of geodetic engineering surveying, investigative studies indicate that this is a challenge (Witte and Heck, 2002).

In the past there have been calls (Enemark, 2001) to amend the focus of surveying curricula from being one that centres greatly on engineering to one that is more interdisciplinary and managerial in its content. The more recent situation, according to the Fédération Internationale des Géomètres [International Federation of Surveyors], reflects a similar pronouncement, with the Fédération calling for a 'paradigm shift' in the way surveying is taught (FIG, 2010). This viewpoint is largely due to their belief in the premise that an extensive transformation of syllabuses is needed in order to create a balance between teaching the core professional competences and introducing students to more generic capabilities (communication, teamwork, learning aptitude, etc.). In addition, there are also more veiled challenges to this educational sector, as Hannah et al. (2008) maintain that the profession has a minimal public profile compared to other occupations, resulting in the surveyor's skills and expertise not being commonly known—which in turn can contribute to low numbers studying the discipline.

Nevertheless, in spite of these challenges, Fairlie (2009) has determined that the future role of a surveyor will see internationalisation and interoperability, the former due to the demands of the global market and the latter due to the requirement for multi-disciplined practitioners. Should this happen, it is fair to presume that the educational sector for surveyors can look forward to continued buoyancy.

3.2 The Irish Educational Experience

In the Republic of Ireland there are approximately seventy-one higher-level courses that contain elements of geodetic surveying. This figure was ascertained having carried out exploratory research into all higher-level programmes, the methodology of which is discussed on page 140. Such enquiry was necessary, as determining the exact number is not a straightforward task owing to the amalgamation of surveying into other subject disciplines. Allan (1995), while discussing this problem, suggests that there are rudiments of surveying to be found, inter alia, in civil engineering, architecture, property, and construction studies. He goes on to state that the discipline cannot be divorced from even the basic studies of law, finance and science. As a result, tuition in geodetic surveying is contained in Irish higher-level courses as diverse as *Applied Building Repair and Conservation* and *Construction Facilities and Energy Management* along with the more archetypal programmes such as *Geomatics* and *Civil Engineering*.

In relation to the structure of such courses, students are afforded the opportunity to pursue undergraduate and postgraduate programmes that contain elements of the discipline. However, amounts of instruction and tuition vary considerably, with some courses only teaching surveying practices for a small number of hours and others centring their entire four-year curriculum on the subject. Such diametrically opposed methods of tuition may appear surprising at first; however, unlike some other European countries (Czech Republic, Greece, Germany, Denmark, etc.) there are no requirements for the licensure[26] of geodetic surveyors in Ireland. As a result, it is possible to engage in surveying practices with only minimal formal education in the discipline, and therefore Irish educational institutions offer periods of tuition as they see fit. Addressing this situation, Prendergast (2006) opined that at a minimum, educational programmes of four years' duration are needed to produce graduates capable of fulfilling the role of a geodetic surveyor, but ideally a five-year framework is needed. Despite such calls, currently there remains little similarity in terms of duration or content between the various surveying programmes offered at Ireland's tertiary level institutions.

3.3 The European Educational Experience

Historically, in Europe, the education of geodetic surveyors has been even more fragmented. This was primarily attributable to many European countries having a dissimilar educational structure than that of the four-year baccalaureate programmes offered in the Republic of Ireland. As a result, when examining educational provision from a European perspective there are two distinct time periods of significance: Pre- and Post–Bologna Declaration.

[26] *Licensure* is the legally enforceable registration of an individual or profession.

The Bologna Declaration itself was an agreement formed in June of 1999 by the various European Ministers of Education to ensure Community-wide adoption of a comparable higher-level educational system. Post-Declaration, twenty-nine member states commenced implementation of an undergraduate bachelor and structured post-graduate system that would enable interstate recognition of qualifications and thereby assist in the mobility and employability of European citizens. Before the adoption of the Declaration, European countries had significant levels of autonomy and prescribed the tuition of higher-level geodetic educational material as they saw fit. For surveyors the effect of this meant that in some countries it was possible to study for one year and obtain a diploma whereas in other countries it took five years.[27] Seeking the explanation for this, Witte and Heck (2002) maintain that historically the profession was primarily active in select regional or national markets, and as a consequence academic programmes were structured specifically for these requirements without consideration for the needs of the global market.[28] Concurrently, the governance of the profession influenced the scope and provision of academic programmes, as some member states conferred qualifications and legally regulated the profession, while others left this task to the professional bodies. Accordingly, in certain European States surveyors had a quasi-judicial function and required a statutory qualification to carry out certain work, whereas in other jurisdictions they did not.

In light of this complexity, the Council of European Geodetic Surveyors (CLEG)[29] in the mid-1990s commissioned an extensive study entitled *The Education*

[27] Similar disparity existed for other higher-level awards, and practices were not just limited to the bestowing of diplomas.
[28] For example, if a regional area was known for having significant natural features such as mines or mountains, surveying programmes' content would focus heavily on these aspects.
[29] The acronym CLEG is widely used in reference to the Council and is derived from its French appellation—*Comité de Liaison des Géomètres Européens.*

and Practice of the Geodetic Surveyor in Western Europe.[30] The report sought, as its title suggests, to examine the function of the geodetic surveyor and the professional education and training they pursue, therefore highlighting the standard that existed in the various countries. The investigation found that countries like Germany had a two-tier surveyor educational system, whereby those attending universities after a minimum study time of four and a half years gained a diploma [*Diplom-ingenieur*] in geodetic surveying that would be comparable to a master's degree in Ireland. In contrast, colleges of applied sciences [*Fachhochschulen*] offered students a three-and-a-half-year diploma that could be compared to an Irish honours-level bachelor's degree. Certain types of geodetic surveying were also state regulated and required a period of professional experience before licensure was granted. In addition the system was somewhat monopolistic, as graduation from the Fachhochschulen did not allow students to practise in all areas of geodetic surveying due to certain disciplines being reserved solely for those that held a university Diplom-ingenieur.

The situation in Austria reflected a similar configuration, although study times were slightly longer, with geodetic surveying programmes being offered in the technical universities of Graz and Vienna that took five years to complete. State regulations also required a graduate to gain a certain amount of work experience before they could obtain a licence for some categories of geodetic surveying. It is worth noting that the road to graduation was even more circuitous, as on average these programmes took students eight years to complete due to compulsory military service. External factors, such as national service, that lengthen the time it took for students to complete a course in geodetic surveying were not unique to Austria. Allan (1995) points to the example of Finland, where at the technical university of

[30] Commonly known as the Allan Report in recognition of its author, A.L. Allan (1995).

Helsinki the five-year geodetic surveying programmes took students an average of seven and a half years to finish due to the aforementioned requirements. However, not all European countries employed such means of educating their surveyors. Finland's neighbours across the Gulf of Bothnia in Sweden had a system somewhat more analogous to the Irish framework, with technician, bachelor's and master's level programmes being offered, albeit at only a small number of educational institutions [Royal Institute of Technology, Stockholm; Institute of Technology, Lund; and Gävle University College].[31]

In the period prior to the implementation of the Bologna Declaration, higher-level courses in surveying were also a relatively niche study option in some European countries. A case in point was Norway, where geodetic surveying education was only available at two universities and two colleges located in the respective cities of Aas, Trondheim, Bergen and Gjøvik.[32]

In the majority of instances, European countries provided students with the choice of either university or college education; however, even this was not a steadfast rule, as in Switzerland higher-level geodetic surveying education was offered at state engineering schools, technician training schools and Federal Institutes of Technology.[33] As was the norm in many northern European countries, certain functions of geodetic surveyors were also state-regulated in Switzerland. This norm, however, was not confined to the northern half of the continent: in the south,

[31] Sweden's progressive stance on surveyor education can be traced back to the time of Gustavus II Adolphus (1594–1632) and the Swedish war against Poland. During this epoch, King Adolphus, tired of being forced to seek surveyors from foreign countries to assist in military advancement, ordered the establishment of a system for educating surveyors in 1628. See Lilje (2003) for a more in-depth account.

[32] Despite their lack of provision for higher-level study in the discipline of geodetic surveying, Allan (1995) found, paradoxically, that surveying was offered as a study option in some Norwegian secondary schools and pointed to the example of the Rud Secondary School in Akershus and the Gauldal Secondary School in Sør-Trøndelag.

[33] Programmes at state schools took three years to complete; technician education required four; and graduation from the Federal Institutes of Technology necessitated four and a half years of study.

the Spanish geodetic surveying market was also legally regulated, with those wishing to practise having first to be registered with the Colegio Oficial de Ingenieros Técnicos en Topografía (Official College of Engineering Technicians in Topography). In order to meet the qualifying criteria of this regulating body, five-year courses in geodetic surveying were offered at technical universities in Valencia, Jaén and Madrid, and three-year programmes at nine other technical universities (Madrid, Avila, Barcelona, Jaén, Las Palmas, Mieres, Valencia, Vitoria, and Mérida). Moreover, Spain was not the only Iberian region to offer a five-year educational model for geodetic surveyors, as a comparable model could be found in Portugal at the Universities of Coimbra and Lisboa (5^{th} year spent in specialised study).

Although five-year syllabuses were common in Europe during the period before the implementation of the Bologna Declaration, there were some cases of early adaptation to the now standardised four-year degree configuration. An example of this can be seen in the Netherlands, where traditionally degrees in geodetic surveying were of five-year duration but were changed to a four-year structure, therefore emulating their adjoining neighbours Belgium, who also had four-year courses in geodetic surveying at two universities and eight institutes of technology. However, it should be noted that not all nations endorsed such change, and highly regulated markets still existed in countries such as Denmark, where in order to get a state licence to become a practitioner of certain geodetic surveying activities, individuals were required to complete a university primary degree coupled with a postgraduate master's degree, and to work in professional practice for a period of three years.

By now it should be clear to the reader that inconsistent educational methods existed for the surveying profession throughout Europe during the mid-1990s. As such problems were familiar across the entire spectrum of higher-level courses and not merely confined to programmes in surveying, sector-wide change was needed, and towards the end of the decade this change emerged in the form of the Bologna Declaration. Whether this provided a remedy to solve all maladies within the European higher-level educational system remains debatable. Undoubtedly, it did produce a more harmonised European higher education system and ensured the collective recognition of qualifications in conjunction with the development of the European Credit Transfer System (ECTS). However, in relation to surveying, state regulatory bodies in some countries continued to influence what was taught, and as a consequence the praxis still saw the existence of many of the previously discussed educational arrangements.[34]

In spite of this, the opening decade of the twenty-first century saw the education of geodetic engineering surveyors expand in Europe. Witte and Heck (2002) estimate that there are over one thousand students entering geodetic surveying courses in Germany each year. From Slovakia, Kopáčik (2002) reports that surveying is now taught at seven different institutes of technology and universities, with both undergraduate and postgraduate programmes being offered. Lisec et al. (2009), commenting on the situation in Slovenia, document how over the last decade there has been a steady influx of students matriculating on the country's surveying programmes. Prior to the changes implemented by the Bologna

[34] Similar to the situation that exists in Ireland, geodetic surveying remains amalgamated into other European higher-level programmes across a diverse assemblage of subjects. Accurately identifying just how many courses there are or to what extent surveying plays is difficult and would require a cadre of transnational support from European colleges and universities. To date, the body of published research does not point to any past attempts at investigating this issue. As a result, analysis of content or quality falls outside the scope of this chapter.

Declaration, students graduated with a diploma that could be compared to an honours bachelor degree in Ireland. Now there are awards made at bachelor's, master's and doctoral level. Lisec et al. (2009) also maintain that in recent years there has been a refocusing of the syllabuses from predominantly an engineering application to a more managerial and interdisciplinary function.

Evidence from Slovenia's neighbours across the Adriatic Sea in Italy illustrates how there are now forty institutes of higher education offering 314 courses in surveying throughout the country (Rinaudo, 2011). Literature also points to one of the European Union's most recently joined members, Romania**,** adapting the Bologna model within its higher-level surveying programmes (Grecea, 2009). A similar report by Weigel and Švábenský (2006) from the Czech Republic suggests that surveying courses in that country have also been modified to be more comparable to the Bologna framework.

From the Scandinavian country of Norway, Leiknes' (2010) research points to an increase in the number of students studying surveying, while from the Nordic country of Finland, Vitikainen (2005) documents how since August 2005 the Bologna model has been implemented and the traditional one-stage master's degree in surveying has now been changed to a two-stage degree and master's course.

Commenting on progress in Hungary, Markus (2005) states that between 2002 and 2006, syllabuses from surveying courses in the country's higher-level institutions successfully implemented the Bologna process. Similarly, Steinkellner (2002), remarking on Hungary's neighbours in Austria, found that the country's accession to the European Union caused significant changes to surveying education that now sees undergraduate and postgraduate courses available since 2001/2002.

3.4 The Global Educational Experience

Looking beyond the borders of European Union, there are reports that higher-level programmes in surveying are flourishing. Yanfang and Xiaobo (2010) document how the Wuhan University in China has four schools out of the institution's twenty-eight involved in the teaching of the discipline. These schools, which are by far the largest in the world,[35] comprise approximately 4600 students and 420 lecturers and offer BSc, MSc and PhD programmes in the subject area.

From Turkey, Öcalan and Tunalıoğlu (2010) declare that the education of geodetic engineers in the country dates back over sixty years, during which time over 12,000 surveyors have been educated with the help of the country's twenty-one surveying engineering departments. In a separate report from Turkey, Özlüdemir, Köktürk and Nurhan (2010) declare that the number of students entering such programmes is increasing exponentially, with 650 students commencing study in 2004 and 1175 in 2009.[36]

The Bologna educational framework is also spreading globally. Bozic, Vasilic and Petrakovska (2010) document how the Ukraine, even though not a EU state, has accepted the model proposed by the Declaration and has begun to reform its educational system, which in turn has led to surveying programmes being offered at both undergraduate and postgraduate level in technical institutions and universities.

Chan (2010), researching the situation in Hong Kong, records how three of the province's eight institutions of higher education currently offer surveying

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[35] Wuhan is at present the largest educational provider of surveying courses. From a historical perspective, surveying and mapping exploits were one of Vladimir Lenin's priorities in the former Soviet Union. As a result, Moscow State University of Geodesy and Cartography (MIIGAiK) held this title up until 1956. See Konecny (2002) for a more detailed history.

[36] Due to Turkey being geographically positioned in both Europe and Asia, it has been classified as a global country for the purposes of this chapter.

programmes, and from 2012 onwards, students studying at undergraduate level have had to complete four years instead of the traditional three.

Reporting on practices from America, Rouch (2010) found that there are approximately twenty academic institutions providing specific bachelor surveying programmes and that syllabuses differ considerably between the various institutions.[37] In view of this, there have been efforts to develop a homogenous surveying education throughout the country, and in 1993, following an extensive investigative study, *The Report of the American Congress on Surveying and Mapping, National Study on Surveying and Mapping Education* was published. Despite such efforts, Rouch suggests that the report's findings and recommendations contained in it were widely criticised by academics involved in the teaching of the discipline, a claim supported by the fact that the report was rejected by the state registration boards.[38] Nevertheless, Rouch extends his claims and maintains that since the report was promulgated, the subsequent intervening period has seen the retiring of many surveying academics and their replacement with less traditionalist tutors who have adopted several of the recommendations put forth in the aforesaid document. Consequently, a more standardised curriculum is gradually being introduced into several American academic institutions.

[37] In contrast to the Irish situation, the primary areas of the profession (cartography, cadastral survey, and geodesy) are taught as distinct discipline majors. However, the American system is comparable to Ireland in some respects, as there are many amalgamated programmes that offer components of surveying.

[38] In America there is a National Council of Examiners for Engineers and Surveyors (NCEES) that governs professional registration and oversees examinations to determine if an individual is permitted to become a licensed surveying practitioner. However, licensure is not harmonised across all states, and as a result surveyors must fulfil criteria and register with individual state boards in each region where they wish to practise.

3.5 Profiling the Future Education of Geodetic Surveyors

In looking to the future educational practices of the geodetic surveying industry, evidence suggests there is still a need for change. The pace of such transformation needs to meet the challenges of both the working environment and key policy drivers who in the twenty-first century expect multi-disciplined surveying practitioners.[39] As education forms part of the bedrock for professional competency, higher-level study programmes' content must be continually examined and modified to ensure students are being taught the most constructive and innovative material. Lisec and Ruiz Fernández (2008) reserve the view that such overhauls should be cyclical due to the proliferation of science and technology. They also claim that examining information on study programmes is central not only to the renovation of educational programmes, but also to the future global mobility of students, researchers and teachers. Witte and Heck (2002) support such views and argue that surveying syllabuses must be continually scrutinised and restructured to reflect changing technological demands and societal developments. Markus (2004) concurs and puts forth the suggestion that the sector now needs programmes that are flexible, tailor-made and cost-effective.

Such sentiments also resonate at the highest echelons of the industry. Evidence of this can be found in the former President of the International Federation of Surveyors, Stig Enemark's comments on global surveying curricula (Enemark, 2005): he proclaimed that surveying lectures are still predominantly based on teaching the traditional disciplines and therefore must change to be more accommodating to contemporary societal demands. President Enemark also strongly

[39] The Royal Institution of Chartered Surveyors (UK) identifies 104 competencies a contemporary surveyor should possess. Hannah et al. (2008) maintain that a figure of approximately 200 is more accurate.

advocates that educators should focus on developing 'management skills' and a culture of 'lifelong learning' amongst their students. In order to achieve this, he believes improved focus on the 'virtual academy' of learning [distance learning courses] is necessary.[40]

At national and international levels there is also evidence to suggest that this is an educational sector that is open to consultation and the recognition of the need to continuously adapt. Confirmation of this can be found in the European Education in Geodetic Engineering, Cartography and Surveying (EEGECS) thematic network—an association established in 2002 with the aspiration of creating opportunities for dialogue and collaboration between higher-level institutes involved in the tuition of surveying. At present the network comprises 114 institutions from twenty-seven different European States and consists of six working groups.[41] As a compendium, these groups provide a forum for consultations and research on core curricula, different pedagogical approaches and generally how best to advance the status and position of the profession globally.

The International Federation of Surveyors has also facilitated the provision of a Surveying Education Database (SEDB) on their website over the last eighteen years. This database provides a platform for academics from educational institutions that offer graduate or post-graduate courses in any surveying discipline to post and share information. At the time of writing, the database contains information from 460 courses at 320 higher-level institutions in 86 countries, and boasts Irish members

[40] There is a growing body of research from the surveying community that supports Enemark's bold statements. Means et al. (2009) have found that e-learning courses are becoming popular because they afford students access to educational material at a time and place that suits them. Gillieron's (2010) research substantiates such a claim and documents evidence from the Swiss Federal Institute of Technology, where a newly introduced online course in geodetic surveying attracts in excess of 26,000 connections per semester from over 160 students around the globe.

[41] The six groups are mandated as follows: Working Group (WG) 1: Undergraduate Education; WG 2: Research; WG 3: Continuous Education; WG 4: Private and Public-Sector Enterprise; WG 5: Mobility of Surveyors/Language Leaning; WG 6: Quality Assurance of Teaching.

from universities and colleges in Dublin, Dundalk, Limerick and Galway. Such efforts suggest a desire by academics to continually adapt the geodetic surveyors' educational system. Whether such change is born out of a need to self-actualise or the ultimatum of obsolescence remains up for discussion; however, Hannah et al. (2008) candidly state that the challenge for the profession is simply to respond to both industry and societal needs or be left behind.

3.6 Chapter Conclusion

The above synopsis has shown that higher-level education in geodetic surveying is an established discipline both nationally and internationally and that many countries are undergoing a renovation of their curricula. International trends and patterns are also moving away from a heterogeneous approach and forming more harmonised methods of educating surveyors.

From a pedagogical perspective, without question, Irish educational offerings will continue to be in a state of perpetual motion as funding, changing societal needs, technological innovation, international practices, students' preferences and stakeholder requirements will structure the future direction of the education of surveyors.

Whether the forecasted changes create the panacea in educational structures expected remains to be seen. However, regardless of debate, Enemark (2009) proclaims that '*No development in the world will take place without having a spatial dimension. No development will happen without the footprint of the surveyor*.' As a result, the permanence of the profession and the continued provision of some form of educational offerings to support those that practise in this area seem assured.

In closing: this chapter has chartered the educational offerings for those seeking to pursue a career in geodetic engineering surveying; however, the central question of the thesis still remains: what level of health and safety education is provided to students who attend these programmes?

To answer this, the next chapter will document, through the provision of a literature review, the extent of health and safety teaching that currently exists in the Republic of Ireland, and what—if anything—is known about the health and safety training that students on geodetic surveying courses receive.

CHAPTER FOUR

A Literature Review of Provisions Relating to a Geodetic Engineering Surveyor's Health and Safety Education

4.1 Introduction

The rationale for this chapter stems from the belief that the process of literature review enables the examination of past research in a chosen field and serves to highlight—through the presentation of an objective synthesis and critique—areas of research that are open to further analysis.

For the purpose of this study, the review has focused on health and safety educational provisions offered to geodetic surveyors from a young age up until they enter the workforce. This approach is based on the premise that by highlighting all available interventions from primary through to tertiary level tuition, a complete overview of a surveyor's educational attainment in the discipline of health and safety can be shown. Support for this approach is found in studies by the European Agency for Safety and Health at Work (EU-OSHA) which state that all levels from '*nursery through to university*' play a role in establishing a prevention culture for later occupational life (EU-OSHA, 2009). As a result, it was deemed necessary to investigate all provisions, as referral to higher-level education alone would only show a segment of the overall educational development. Furthermore, as it is not uncommon for an individual to learn the trade of a geodetic surveyor through work-based learning and not higher-level specialised study, the role of middle education is of additional significance to this profession.

As stated in the opening paragraphs, the review does not attempt to examine education and training offered to individuals who have entered the workforce; this is primarily due to the myriad of optional programmes available and an inability to determine which ones an individual may pursue. The review does, however, make reference to mandatory training required by law.

4.1.1 Aim of the Review

The aim of this review is to investigate and critique provisions relating to the health and safety education of geodetic surveyors in the Republic of Ireland using available literature.

4.1.2 Objectives of the Review

To achieve the aforementioned aim, the following objectives have been set:

I. Examine the legal requirements for health and safety education and the ramifications of failing to abide by such legislative provision.
II. Analyse current provisions from the primary, post-primary and higher-level educational sectors relating to health and safety education.
III. Discuss mandatory training requirements for geodetic surveyors.
IV. Identify, as a result of the review, opportunities for further research relating to the education of geodetic surveyors in the area of health and safety.

4.1.3 Structure of the Review

The review begins by outlining in section 4.2 the legal requirements for health and safety education/training in the Republic of Ireland, with particular reference to geodetic surveyors. From there section 4.3 demonstrates the importance of abiding by such legislative provisions, through the illustration of legal cases that have come before the judiciary on the issue of health and safety education and training. Sections 4.4 to 4.7 investigate current efforts within the educational system relating to health and safety, while sections 4.8 to 4.9 details sector-specific efforts from the construction industry. The review finishes with an overall conclusion in section 4.10

which reiterates the principal issues raised and summarises the main reasons why a subsequent research project is both required and justified.

4.2 Legal Requirements for Health and Safety Education and Training

The Safety, Health and Welfare at Work Act 2005 (S.I. No. 10 of 2005)[42] is the Republic of Ireland's primary legislative instrument for the protection of every employee's occupational wellbeing. It places a statutory obligation on employers to ensure health and safety training is provided to all employees to an extent that is reasonably practicable.

In total, the requirement for training is referred to over twenty-nine times in sections 8, 10, 11, 13, 25, 26, 34 and 58 of the document. As a compendium, the various sections outline a duty to provide training upon recruitment that is in a form, manner and language understandable to the employee. Such training must be repeated periodically and in the event of changing circumstances relating to practices at work, systems of work or the onset of new technologies. An employer must also facilitate a consultation process with employees to determine the extent of training they require, with the resulting interventions being given during working hours and without fiscal loss to the participant. Furthermore, the Act places an explicit requirement on employers to ensure that safety representatives receive adequate training.

Employees are also duty bound: each individual is required to attend training opportunities and undergo necessary assessments. Once trained, an employee is obliged to abide by all instructions given and to use both articles and systems of

[42] S.I. No. is the acronym used to denote the term *statutory instrument number.*

work in accordance with their tuition. The Act also states that it is an offence for an employee to misrepresent the levels of training they have attained.

Aside from the focus of employers and employees, the Act also addresses the role of the Health and Safety Authority (HSA)[43] in training, conveying that theirs is one of promotion, fostering and encouragement. The latter passages of the Act also express the right of government to issue further ministerial regulations on matters of employee training as they see fit.

In reviewing the Act, it becomes apparent that the document places considerable emphasis on the necessity for occupational health and safety training and does not support an autodidactic approach to employee education. Nowhere is the occupation of geodetic surveying expressly mentioned; however, this is unsurprising, as the Act is a primary legislative instrument aimed at all general occupations including that of geodetic surveying.

Although emphatically promoting training, the Act also reinforces the nine General Principles of Prevention, where training is seen as the last option in ensuring the protection of occupational wellbeing. Hence, it is arguable that as an absolute minimum, a company should be providing training to geodetic surveyors and that such training only serves as an accompaniment to an overall safe system of work.

Also of significance is the fact that the Act elucidates the meaning of a '*competent*' person in the context of health and safety, defining it as someone who has been shown to possess the relevant '*training, experience and knowledge*' (section 2.2a). The inclusion of training as a prerequisite to achieving competence has far-reaching ramifications for all industries and occupations. In the context of

[43] The Health and Safety Authority (HSA) is the national statutory body with overall responsibility for the administration and enforcement of health and safety at work in Ireland.

this study, the definition implies that in order for geodetic surveyors to be regarded as competent, they must, by law, be trained in occupational health and safety, and no amount of on-the-job experience or personal knowledge alone will suffice in place of this requirement.

More broadly, it may be argued that the level of health and safety training a geodetic surveyor receives in formalised education is not of great relevance, as the 2005 Act places such pertinence on the role of employee training in the workplace. However, in rebuttal, it can be claimed that by removing health and safety training entirely from the education system and relying solely on the duties of an employer as per the 2005 Act, there is no guarantee of the quantity or quality of tuition an employer may present to an employee. Similarly, it can be contended that those tasked with the provision of such in-house training are often self-regulated and neither open to external examination nor in abidance with the terms of the Qualifications and Quality Assurance (Education and Training) Act 2012 (S.I. No. 28 of 2012).

Regardless of the fervour of debate, failure to abide by any of the Act's legislative provisions carries certain penalties. Investigative powers of HSA inspectors are extensive, and court-imposed fines can reach €3,000,000, with or without imprisonment for a term of up to two years.

4.2.1 The Safety, Health and Welfare at Work (General Application) Regulations 2007 (S.I. No. 299 of 2007) (as amended)

The General Application Regulations—as their title suggests—are a secondary legislative instrument that applies to generally all places of work. They serve as an accompaniment to the primary 2005 Act and are usually enforced in unison. The

Regulations stipulate the need for employee training in sections 40, 67, 72, 98, 107, 108, 109, 125, 130, 139, 144, 163, 173 and Schedule 3. In summary, these sections pertain to the provision of training relating to self-propelled work equipment, the use and limitations of personal protective equipment, working at height, noise/vibration assessment and reduction, explosive atmospheres, manual handling; display screens, first aid, and sensitive risk groups.

Similarly to the 2005 Act, the Regulations do not specifically address geodetic surveying but do encompass the occupation in the generality of their application. In relation to training, the Regulations seek for it to be afforded to geodetic surveyors should their work relate to any of the systems, articles or categories of work previously mentioned.

The Regulations also illustrate the significance of the definition of ‘competent’ in the 2005 Act, which as explained in section 4.2 of this document stipulates training as a prerequisite. As a result, sections 13, 28, 30, 40, 42, 43, 50, 51, 52, 53, 55, 57, 73, 74, 81, 88, 89, 107, 124, 141, 170 and 173 of the Regulations are all of possible relevance to the training requirements for surveyors. In summary, they legislate for the use of competent persons in relation to a host of work-based tasks that include: repairs, inspecting, testing and operation of certain equipment, determining maximum safe working loads, examining and testing lifting equipment, issuing of permits to work, health surveillance, portable appliance testing, fire detection and servicing, explosive atmosphere assessment, and noise sampling, along with tasks and articles as diverse as cranes, electricity, scaffolding and eye-tests — none of which correlate to the work of geodetic engineering surveyors. This assertion is supported by the body of research literature that does not indicate instances of these surveyors partaking in any of the above tasks, so tentatively it may be argued that the specific training requirements relating to competence as outlined in the General Application Regulations are non-applicable to this occupation.

4.2.2 Additional Legislation on Health and Safety Education and Training for Geodetic Surveyors

Further literature analysis reveals that there is a litany of additional legislation dealing with the topic of occupational safety and health training. For example, areas and fields as diverse as chemicals, mines, quarries, carriage of dangerous goods, confined spaces, underground services, and electricity, are all detailed in legislation and codes of practice. In general, they have little to no significance for the geodetic surveying profession and do not specify levels of required training attainment for the profession.

A review of legislation from the Oireachtas and the Irish Statute Book also illustrates very few laws specifically aimed at training for surveyors. In fact, out of the 376 references to surveyors in legislative text, over fifty per cent focus on marine or shipping surveys. The mention of training for land-based surveying in the remaining references is practically non-existent, with the Mines (Surveyors and Plans) Regulations, 1970 (S.I. No. 78 of 1970) containing the most recent stipulation of a requirement to appoint competent individuals for surveying. Prior to this, the last reference to land-based surveyors and training can be found in the Land Purchase Act (05/02/1924), which stated a demand for competence in relation to making maps of the land. In both instances it is fair to assume that neither of these examples has any real bearing on the type of topographical land surveying at the centre of this report, as the former deals with sub-terrain surveying and the latter cartography.

Such scarcity of legal references to mandatory training for land-based surveyors is not typical of the other surveying professions. Both the Building Control Act 2007 (S.I. No. 21 of 2007) (as amended) and the Recognition of Professional Qualifications (Directive 2005/36/EC) Regulations 2008 (S.I. No. 139 of 2008) (as amended) clearly outline levels of training and education required to allow the designation of 'Quantity Surveyor' and 'Building Surveyor' but do not attempt to address the requirements for geodetic surveying. The profession is therefore predominantly dependent on more universal legislation in the form of the 2005 Act and the 2007 Regulations to detail the necessity for health and safety training, as industry-specific statutory legislation does not exist.

4.2.3 Transposition of the Construction Health and Safety Regulations

Such exclusion as detailed in section 4.2.2 is not limited to just the *training* of geodetic engineering surveyors. The text of the Safety, Health and Welfare at Work (Construction) Regulations specifically excludes the profession despite being the State's attempt to secure the occupational health and safety of those that work in the construction sector. To comprehend this literature finding, one needs to understand the relationship between European directives and Irish health and safety regulation.

In essence, the Safety, Health and Welfare at Work Act 2005 (S.I. No. 10 of 2005) overcomes its generic nature by allowing—in accordance with Part 6 of the Act—regulations to be developed and implemented to service specific industries. Such regulation is known as secondary legislation and serves as an accompaniment to the aforementioned primary legislation.

In the domain of health and safety, the development of regulations is derived from EU directives—binding legislative provisions that member states must transpose into national law within a given time period. The foundation for directives specifically relating to health and safety can be found in text pursuant to Article 153 in the Treaty on the Functioning of the European Union. This Article outlines how the EU shall '*support and complement the activities of the Member States . . . in particular the working environment to protect workers' health and safety . . . by means of directives*'. Once formed, member states are granted autonomy to decide how best to implement the directives; as a result, commonality is not guaranteed. The directives essentially lay out *minimum* standards that must be met, thus allowing each State to enforce stricter requirements should they see fit. Accordingly, should a member state fail to implement a directive sufficiently (in time or context), they may then face sanction from the European Union.

In the Republic of Ireland, transposition of directives relating to occupational health and safety lies within the remit of the Department of Enterprise, Trade and Innovation (DETI), a division of government tasked with increasing employment and national competitiveness. This department has a sub-division containing a *Health and Safety Policy Section* comprising 15 members. The Section works to ensure the correct transposition of directives, in tandem with the Health and Safety Authority (HSA).

According to data available (Department of Enterprise, Trade and Employment, 2010), the Section's primary role is to:

- Formulate and develop policy in relation to workplace health and safety, including reviewing legislation and work environment developments on an ongoing basis.
- Monitor and support the activities of the HSA.

- Advise and inform the minister and management of the Department on matters relating to health and safety.
- Interact with the HSA and other government departments, state agencies and the European Commission on matters relating to workplace health and safety.

As a result, the HSA is under the aegis of the Section, which in turn is accountable to the relevant minister of state. A tripartite approach to the formation of regulations is completed by involving an Industry Representative Council: a panel of experts derived from an industry environment and the social partners.[44] Together they draft regulations from the given directive, which are then enacted into statute by ministerial signing.

Development of legislation has been done in this manner since Ireland's entry into the European Community in 1973. However, occupational health and safety legislation had existed for many years before, in both primary and secondary format. Since its first Statutory Instrument appearance in the verbosely titled 1802 Act for the 'Preservation of the Health and Morals of Apprentices and Others Employed in Cotton and Other Mills and Cotton and Other Factories',[45] occupational health and safety legislation has steadily evolved. By the turn of the twentieth century, decree of major reform could be seen in the Factories and Workshop Act.[46] This 1901 Act was also the first—in accordance with Section 79—to allow subsequent regulation be made in the field of occupational health and safety.

By the middle of the twentieth century, the Factories Act (S.I. No. 10 of 1955) had been introduced. This Act provoked change, but with its remit limited to 'factories' it had minimum effect on industry as a whole. Legislators attempted to

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[44] Social Partners: Representatives from trade unions, main employment groups, voluntary organisations etc.
[45] 42 Geo. III c.73.
[46] I EDW. VII. C.22.

overcome this deficiency by introducing various instruments that addressed areas such as mines and quarries, offshore installations, and the construction industry. However, an all-encompassing piece of legislation did not appear until Europe issued Directive 89/391/EEC, known as the Framework Directive,[47] which in turn led to the creation of the Safety, Health and Welfare at Work Act 1989 (S.I. No. 7 of 1989) and subsequent modern-day legislation.

Nevertheless, throughout the twentieth and twenty-first centuries the legislative health and safety Acts have not mentioned geodetic engineering surveying. This in itself could not be considered an anomaly, as secondary legislation is often where sector-specific terms and individual professions are mentioned. In turning to the sector geodetic engineering surveyors inhabit, December 1975 saw the introduction of the Republic of Ireland's first construction health and safety legislation[48] in the form of S.I. No. 282 of 1975: the Construction (Safety, Health and Welfare) Regulations. This Instrument defined what constituted a construction 'site'—a definition that did not purport to exclude site surveying (geodetic engineering surveying). The 1975 Regulations were subsequently updated in November 1988 with the introduction of The Construction (Safety, Health and Welfare) (Amendment) Regulations (S.I. No. 270 of 1988), which again did not attempt to alter the definition.

Up to this point, one could argue that the Regulations did not specifically mention surveying, but neither did they purposely exclude it. The legitimacy of this

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[47] Framework Directive: On the 12th June 1989, the Council of the European Community adapted Directive 89/391 measures to ensure improvement in the safety and health of workers at work – commonly referred to as the Framework Directive. *Euro-Lex Official Journal L 183, 29/06/1989 pp. 0001-0008.*

[48] Prior to 1975, no 'Construction' Health and Safety Regulation existed since the founding of the State. There was, however, one preceding instrument closely related to the topic: The 1959 Building (Safety, Health and Welfare) Regulations (S.I. No. 227 of 1959). This was revoked with the enactment of the 1975 Regulations.

argument, however, ended in June 1995, with the introduction of the Safety, Health and Welfare at Work (Construction) Regulations (S.I. No. 138 of 1995). This Instrument, although revoking the 1975 Regulations, once again defined the meaning of a construction 'site', but conversely went further and defined the meaning of 'construction work', as follows:

> Carrying out of any building, civil engineering or engineering construction work and includes . . . the construction, alteration, conversion, fitting-out, commissioning, renovation, repair, upkeep, redecoration or other maintenance . . . decommissioning, demolition or dismantling of a structure. The preparation for an intended structure including site clearance, exploration, **investigation (but not site survey)** and excavation, and laying or installing the foundations of an intended structure . . . [emphasis added]

As a result of this definition's wording, the process of 'site surveying' was excluded from the meaning of *construction* and in turn the regulatory text. The revocation of the 1995 Regulations in October 2001 and the introduction of that year's Safety, Health and Welfare at Work (Construction) Regulations (S.I. No. 481 of 2001) again saw the retention of the 1995 definition.

Having seen no further adjustment to the text of the 1995 definition in a 2003 amendment (S.I. No. 277 of 2003), the next major change to health and safety construction regulation came in September 2006 with the introduction of the Safety, Health and Welfare at Work (Construction) Regulations (S.I. No. 504 of 2006). This Regulatory text saw amendments in the guise of S.I. No. 130 of 2008 and S.I. No. 423 of 2008, but still retained the original 1995 definition that excludes the processes of site surveying. The second decade of the twenty-first century saw further amendments to the 2006 Regulations in 2010 (S.I. No. 523 of 2010), 2012 (S.I. No.

461 of 2012 & S.I. No. 481 of 2012), and 2013 (S.I. No. 182 of 2013), none of which resulted in the definition being changed. The final major regulatory change came in the form of the Safety Health and Welfare at Work (Construction) Regulations 2013 (S.I. No. 291 of 2013), an instrument that again saw no changes to the text of the 1995 definition relating to surveyors. A synopsis of this information can be seen in Table 1.2 below.

Although no further regulatory text has been produced, in 2010 the HSA published a ten-page guidance document aimed at clarifying the convoluted definition of construction work for contractors and clients who may have difficulty determining whether their works fall within the scope of the definition. Again, this document illustrated that the task of site surveying was clearly excluded (HSA, 2010*c*).

Table 1.2 Chronological Amendments/Revocations to the Irish Construction Health and Safety Regulations

Safety, Health and Welfare at Work (Construction) Regulations	**Year of Publication**	**Text of the Definition of Construction Work**
S.I. No. 282	1975	No exclusion of site surveying
S.I. No. 270	1988	No exclusion of site surveying
S.I. No. 138	1995	Site surveying excluded
S.I. No. 481	2001	Site surveying excluded
S.I. No. 277	2003	Site surveying excluded
S.I. No. 504	2006	Site surveying excluded
S.I. No. 130	2008	Site surveying excluded
S.I. No. 423	2008	Site surveying excluded
S.I. No. 523	2010	Site surveying excluded
S.I. No. 461	2012	Site surveying excluded
S.I. No. 481	2012	Site surveying excluded
S.I. No. 182	2013	Site surveying excluded
S.I. No. 291	2013	Site surveying excluded

Understanding could be granted to Irish legislators who drafted the text, and accountability placed on their European counterparts, if the Directive from which the Construction Regulations was transposed specifically stipulated that surveying was to be excluded. However, this is not the case. Nowhere in Directive 92/57/EEC or its corrigenda[49] is there a requirement for member states to exclude site surveying from the definition of construction work. In fact, the term *surveying* or *site survey* is never once mentioned.

It is also worth noting that no exact definition of construction work appears in the said Directive. Instead, Article 2(a) of the text denotes what constitutes a construction site:

> A temporary or mobile construction site means any construction site at which building or civil engineering works are carried out

Also it presents a non-exhaustive list in Annex 1 of the document of what constitutes such work:

> Excavation; earthworks; construction; assembly and disassembly of prefabricated units; conversion or fit-out; alterations; renovations; repairs; dismantling; demolition; upkeep; maintenance (painting and cleaning work); drainage

Presently, Europe has no community body for the unified enforcement of health and safety.[50] There is, however, a Senior Labour Inspectors' Committee that was formed in 1995 following Council Directive 95/319/EC. They are mandated to give 'opinion to the [European] Commission on all problems relating to the enforcement by the

[49] Corrigenda: corrections made to a published article.
[50] The European Agency for Safety and Health at Work (EU-OSHA) fulfils an avuncular advisory role to member states, but do not engage in enforcement activity.

Member States of community law on health and safety at work'. This Committee has already carried out a European Construction Inspection Campaign in 2003, which revealed a difference in the enforcement of legislation between member states, thus showing that disparity in the way Health and Safety Directives are implemented is not entirely new (EU-OSHA, 2004).

Whether Irish legislators exercised too much autonomy and transposed Directive 92/57/EEC incorrectly is arguable; nevertheless, at present, site surveying remains excluded from the statutory definition of what constitutes construction work in the Republic of Ireland and the associated protection the Safety, Health and Welfare at Work Construction Regulations provide.

4.3 Case Studies from the Courts

Regardless of the appreciable quantity of exclusions contained in the Act and Regulations, the issue of safety training and education has come before the judiciary on many occasions. This has resulted in awards for those deemed not to have been afforded adequate training (*Meus v. Dunnes Stores*, 2014; *Hetherton v. IBM*, 2003), and the imposition of fines for those found culpable of not providing adequate training (*HSA v. Westabbey Developments and Oyster Homes, 2002*; *HSA v. Galway County Council*, 2004; *DPP for HSA v. Gleeson Quarries*, 2009).

In relation to defending a claim, the provision and proof of adequate training has also served as an acceptable defence in some legal challenges (*Clabby v. Global Windows and An Post*, 2003). In certain cases it has led to the dismissal of claims and the awarding of recriminating costs for the accused (*Kent v. South Eastern Health Board/Waterford Regional Hospital*, 2010).

In instances where companies have been found to have provided sufficient training prior to an accident or incident, even if such an accident or incident was a direct fault of their business's undertaking, those claiming have seen their awards reduced because the courts found them guilty of contributory negligence (*McGarry v. Dawn Meats*, 2006; *Barry v. Dunnes Stores*, 2013)

From a monetary perspective, recent fines for the charge of failing to provide adequate training have been imposed as high as €350,000 (*DPP for HSA v. Health Services Executive*, 2013). Some paradoxes do, however, exist as in certain instances the courts have found a worker's experience to be a credible defence for allegations of failing to provide training (*Coffey v. McNicholas Utilities*, 2003) but, in general, findings from the court demonstrate the seriousness of allowing untrained employees to engage in work activity, and reinforce the need for adequate health and safety education.

In the majority of cases, charges of failing to provide training and any subsequent award or fine are as a result of an accident or incident. Nevertheless, failure to provide training is a legal offence, as outlined in part 4.2 of this report, and an employer can be brought before the courts without the occurrence of an accident or incident once the prosecution can demonstrate failure to abide by a legislative provision. Conversely, this also means that a claimant could bring a case seeking an award in an instance where training has not been provided, even if no accident has occurred. For this to be successful, some amount of loss must be established; however, such a loss can be purely psychological, as demonstrated by *Lynch v. Aer Rianta*, 2006, in a case that saw the High Court award an airport receptionist approximately €15,000 for stress caused by a lack of training in how to react to a hoax bomb threat. This highlights the pertinence of comprehensive health and safety education.

The need for such education has never been more apparent than now, with issues of vicarious liability relating to health and safety reaching the Supreme Court (*Lynch v. Binnacle Ltd and Cavan Co-Op Mart*, 2011) and forecasted Irish corporate manslaughter legislation.[51] In relation to geodetic surveyors and the industries they inhabit, the prosecution service are increasingly focusing their attention on the construction sector, and there is significant evidence to suggest that judges dealing with this industry are moving towards the imposition of custodial sentences on those found in serious breach of health and safety laws.[52] Substantiation of this can be found in the convictions of Mr Daniel Lynch, a mechanical excavator driver who was sentenced to three months in prison for failing to take due regard of training and instruction provided by his employer (*DPP for HSA v. Daniel Lynch*, 2009), and the conviction of Mr Michael Scully, a Senior Engineer with Clare County Council, who was sentenced to twelve months in prison for failing to control his undertaking as a site manager (*HSA v. Clare County Council and Michael Scully*, 2010). In both cases, sentences were suspended for two years, but they do serve to highlight the seriousness with which the judiciary are viewing health and safety breaches within the construction industry.

Such views resonate with those of the United Kingdom Courts, where the Health and Safety Executive (HSE) in conjunction with the Crown Prosecution

[51] See Corporate Manslaughter Bill 2016 (No. 33 of 2016) sponsored by Deputy Jonathan O'Brien.

[52] The most recent reports from the Law Reform Commission (2017) suggest that between the years 2005 and 2015 there were 292 prosecutions for health and safety offences. Of which 66 were individuals and 226 were corporate offenders. 91% pleaded guilty. Individuals were fined between €200 and €50,000 and corporate offenders were fined between €400 and €2 million. Other sanctions imposed during this time period included 5 applications of the Probation of Offenders Act 1907, 3 Community Service Orders and 13 suspended sentences. There were also 2 charitable donations and a compensation order to be put on trust for the daughter of a deceased individual.

Service (CPS) have in recent times successfully prosecuted construction company directors in cases that have resulted in actual jail terms. One example can be seen in *CPS v. Cooper*, 2009, where the defendant, Mr Colin Cooper, was sentenced to one year in prison following the death of an untrained twenty-year-old employee on a construction site (HSE, 2009). More recently, January 2011 saw the first successful prosecution in the UK under the controversial Corporate Homicide Act 2007 (Chapter 19), in a case which saw Cotswold Geotechnical Holdings Ltd fined UK£385,000 following the death of an employee as a result of a trench collapse at a construction site (*CPS for HSE v. Cotswold Geotechnical Holdings Ltd*, 2011). Given the subject matter of this report, it is noteworthy that at the time of death, the person was engaged in a surveying operation. This has not been the only recent surveyor fatality, as March 2012 also saw the death of Mr Richard Caddock, a surveyor employed on the M25 motorway project in the UK. In this case, the deceased man's employer was found guilty of not ensuring safety at work and fined nearly £300,000 (*SHP*, 2012).

In summary, precedent has been set both nationally and internationally for the prosecution of employers found not to have afforded adequate health and safety training to their employees. Such a significant duty of care can lead to criticism from employers, who may argue that individuals should come to the workplace already in possession of some health and safety knowledge. Such a sentiment is comparable to EU-OSHA's (2009): that a dual approach of workplace and classroom learning is widely recognised as a major contributory factor in ensuring occupational wellbeing. At the highest level of governance, the European Commission supports the premise that a society which integrates safety tuition into all levels of its education system creates a catalyst for safer work practices and a safety-conscious culture (COM, 2007). For geodetic surveyors this means that safety education should not merely begin at the workplace, but should be integrated throughout all stages of formalised education. As a result, the following sections of this report attempt to outline the degree of safety taught throughout the educational system in the Republic of Ireland that a geodetic surveyor may be exposed to.

4.4 Primary School Education Review

It is a known axiom that the human learning process is most productive at an early age. Because of the level of continuous protection needed to keep an inquisitive child safe, parents are tasked with teaching pre-school children what is ‘good’ and what is ‘bad’. This primitive grouping of objects, actions and experiences provides children with their first introduction to health and safety. Published literature accords to this belief, with Tinsley (2003) documenting how children learn skills related to self-protection from the repeated practice of behaviours in their home environment. Oskamp and Wesley-Schultz (2004) suggests that the family nucleus provides a model of attitudes and behaviour for a child to emulate, thus concurring with the earlier writing of Wiehl and Tinsley (1999), who document how children’s attitudes to self-protection tend to be more ‘*similar than dissimilar*’ to that of their parents in terms of role modelling.

These early rules on staying safe and healthy, according to Clarke and Dawson (1998), are often based on principles of obedience that do not require the child to think or evaluate—as this has been performed by the adult. However, Robertson (2009) argues that role modelling does not provide children with enough information to cognitively understand and practise perennial safe behaviour. To achieve this, formalised pedagogy in the discipline of health and safety is essential, aimed at imparting the skills children need to independently evaluate what is hazardous and detrimental to their wellbeing. In support of Robertson's theory, Marotz (2011) cites numerous studies that claim the aetiology of safe behaviour in children is linked to education. Green and Hart (1998) document how children accept safety as primarily their own responsibility, once taught the fundamentals.

On an international level, EU-OSHA believe that tuition in risk prevention should permeate early education systems, with a view to making '*children aware of the dangers in their environment and what they should do to help make themselves and those around them safer*' (EU-OSHA, 2009). On a global level, the United Nation's Convention of the Rights of the Child seeks to '*ensure that all segments of society, in particular . . . children, are informed, have access to education and are supported in the use of basic knowledge of child health . . . and the prevention of accidents*'.[53] Primary schools therefore have the potential to be the medium for delivering such early tuition. In line with this view, Hayes (2009) documents how children entering primary school are taught to identify specific situations and evaluate appropriate actions, therefore learning their first tentative steps in self-preservation of personal safety and health.

In Ireland, the National Council for Curriculum and Assessment (NCCA)[54] has also recognised the potential to instil a safety culture in young children, and in October 2007 released a report in conjunction with the Health and Safety Authority (HSA) entitled *Mapping Health and Safety in the Curriculum*. This report was concerned with evaluating current health and safety provisions within the early

[53] Pursuant to Article 24. 2 (e).
[54] The NCAA was established in 2001. Its role, pursuant to section 41.1 (a), (b) of the Education Act 1998 (S.I. No. 51 of 1998) (as amended), is to advise the Minister for Education and Science on issues relating to 'the curriculum for early childhood education, primary and post-primary schools and the assessment procedures employed in schools and examinations on subjects which are part of the curriculum'.

childhood, primary, and post-primary educational system. The findings indicated that there is support for developing health and safety in the primary school curriculum, but at present there is more emphasis on *health* rather than *safety* education. The report discussed the feasibility of implementing a health and safety award, and suggested computer-assisted learning as an effective way of promoting the discipline. However, despite the intentions of the NCAA and the HSA, health and safety remains excluded as a standalone subject from the curriculum of primary schools in the Republic of Ireland.

Aside from the state-structured curricula, optional safety intervention programmes are another way of supplementing safety education into the primary level system. The HSA and Junior Achievement Ireland[55] recognise this and administer a primary school intervention programme for 5th and 6th class pupils known as *Keep Safe*. This programme aims to convey an awareness of personal and home safety by teaching children how to identify hazards and assess risks which they may encounter in everyday life (road safety, water safety, fire safety, etc.). The programme is run in conjunction with local agencies and organisations that have responsibility for public safety. Its content is largely derived from the *Bee Safe* scheme[56] which is operational in Northern Ireland's primary schools. However, although similar in content, the *Keep Safe* programme is far less prevalent than its cross-border counterpart. Investigations have revealed (HSA, 2018*b*) that *Keep Safe* has only been provided to approximately 5,000 children since its inception in 2009, whereas *Bee Safe* in a nine-month period alone (September 2005 to June 2006) was taught to over 13,000 children, a figure which represents 54% of primary seven (age

[55] A charity established in 1995 that imparts life skills and gives social development advice.
[56] Safety intervention programme established in 1990 aimed at equipping 10–11 year olds with the skills needed to identify danger and practise safe procedures; it covers a diverse range of topics, such as bus safety and tobacco awareness.

10–11) pupils in Northern Ireland (NIBSP, 2005). Children based in the Republic of Ireland are therefore at a distinct disadvantage in relation to access opportunities.

The ramifications of such limited access are difficult to quantify without relying on anecdotal evidence. However, academic research has consistently shown that safety intervention programmes have significant merit for primary school children (Fredrick et al., 2000; Hewitt et al., 2001; Kendrick et al., 2007; Blake et al., 2008; Bollig, Wahl and Svendsen, 2009). Even single-session safety interventions can have a positive effect on children (Morrongiello and Kiriakou, 2006). Still, it must be stated that Collard et al. (2010), when discussing primary school level intervention programmes, document how only positive findings are usually published and that such positive findings are largely based on self-reporting from an age group that is highly susceptible to social desirability biases. Despite this caveat the advantages of such schemes are recognised by the HSA, and they have outlined a commitment to expand their activities within the education sector at primary level through the use of the *Keep Safe* initiative (HSA, 2018*a*). However, the same report illustrates that the provision of the initiative will be extremely low, with six *Keep Safe* programmes proposed in 2018 (HSA, 2018*a*).

Upon evaluating the United Kingdom's approach to the provision of such programmes, Ireland's efforts seem even less significant. Research carried out by the Royal Society for the Prevention of Accidents (RoSPA, 2003) illustrates how the UK has approximately 200 schemes comparable to *Keep Safe*—albeit under different names, such as Junior Citizen, Safety in Action, Crucial Crew, Safety Zone, Operation Streetwise, and Safety Carousel. Collectively, these courses are known as LASER Schemes (Learning About Safety by Experiencing Risk) and are regulated through assistance derived from the Department of Health.

In addition, the UK has introduced child safety centres across its mainland. These centres, of which there are at least eleven, were first established in Milton Keynes in 1994. They offer teachers the opportunity to bring pupils to an interactive environment where many hazards are staged in a realistic yet controlled manner. The centres aim to allow children to identify hazards, assess the risks and suggest suitable control measures to a myriad of representative scenarios that they might encounter throughout life. These centres tend to be well patronised, with some reporting yearly attendance in excess of 20,000 children (Milton Keynes, 2006). In relation to assessing the value of such centres, a useful longitudinal case study by Lamb et al. (2006) found that they improve knowledge and performance retention of children on a host of safety issues. Despite investigation, no comparable facilities could be found in the Republic of Ireland. Nevertheless, the HSA has stated: '*Education is the key to fostering a culture of safety and health which will heighten awareness and keep young people safe and healthy in the home, school, community and workplace*' (HSA, 2011*b*).

In support of this position, the HSA has sponsored events such as the Primary Science Fair at the BT Young Scientist and Technology Exhibition, where competitors are obliged to provide evidence of a '*safety element*' in their project. There is a similar promotion of issues relating to farm safety due to the correlation between farming accidents and children.[57]

Leaving aside national interventions, on a community level, teachers and management at individual schools have an ability to both facilitate and instigate tuition in the fundamentals of health and safety. The HSA recognises this and in recent years has developed teacher in-service training and e-learning courses aimed

[57] The HSA documents how farming is the only high-risk industry that must deal with the presence of children, and that one in every five fatal farm-related accidents involve minors (HSA, 2007*a*), a ratio that translate to a total of 23 child deaths on farms between the years 2007-2016.

at increasing health and safety competence (HSA, 2011*c*). These courses contain all the rudiments needed to convey basic tuition on health and safety matters. However, subsequent literature analysis has revealed that only 1500 primary school teachers availed of this service (HSA, 2012), resulting in the programme being suspended in 2014. This figure represents barely 4% of the 35,669 primary level teachers in the Republic of Ireland.[58] Furthermore, the overall purpose of such training could be regarded with some degree of ambiguity. In recent years, five primary schools have been served with Improvement Notices by the HSA,[59] despite €340m being allocated for redevelopment of dilapidated school buildings (Sheehan, 2010). Anecdotally it can therefore be argued that to address such problems, teachers may be asked to assist in any area of safety management, from risk assessment to fulfilling the role of a safety representative, thus leaving little time for the additional extracurricular activity of *teaching* safety. Evidence supporting this conjecture is already clearly found in facets of the post-primary sector (see section 4.5) and as a result, emulation at primary level is possible. One can argue that such an approach would be even more understandable in a primary school environment, as the children's ages consign them to the taxonomy of a '*sensitive risk group*' as per the Safety, Health and Welfare at Work (General Application) Regulations 2007 (S.I. No. 299 of 2007). This can result in priority being placed on preserving their health and safety instead of attempting to impart information on health and safety posterity measures.

In relation to facilitating safety education, school management have the ability to instigate further opportunities for tuition by availing of the services of numerous Irish external agencies, for example Teagasc, regional county councils, the Road Safety Authority and Bus Éireann, all of whom provide learning material in the

[58] 2016–17 Department of Education and Skills figures based on the number of allocated posts at the end of the school year.
[59] Pursuant to Section 66 of the Safety, Health and Welfare at Work Act 2005 (S.I. No. 10 of 2005).

area of health and safety for children (Nolan, 2007; KCC, 2011; RSA, 2011*a*). However, in most cases, such programmes are facilitated at the discretion of school management.

4.4.1 Conclusion from Primary School Education Review

Despite the intentions of regulatory bodies, health and safety education remains non-compulsory for primary school students in the Republic of Ireland. In instances where tuition is given, it is presented through cross-curricular study and not as a standalone subject, which according to EU-OSHA (2009) is typical of the majority of European countries.

In relation to educational safety intervention programmes, evidence indicates that initiatives such as the *Keep Safe* programme are of value. However, past provision and present forecasts for the programme's delivery are extremely limited, leaving Irish students at a distinct disadvantage compared to their international counterparts.

Attempts by the HSA to provide educational resources to teachers were also shown to have possible limitations. Nevertheless, the work of teachers and external parties should not be undervalued, as the review indicates there are some good examples of facilitating education for children in the discipline of health and safety. However, in summary, it is possible for a primary school pupil to complete eight years of formative education without any formalised tuition in health and safety. For future geodetic surveyors this means that their early education may or may not incorporate tuition in concepts of health and safety.

4.5 Post-Primary School Education Review

Secondary school for some students presents their last opportunity for state-sponsored tuition in health and safety prior to entering the workforce. Relatively recent figures from the Department of Education and Skills show that out of the 58,000 Leaving Certificate candidates, 30% will not advance to third-level study (DES, 2011*a*). For geodetic surveyors, higher-level education is not compulsory, and anecdotal evidence would suggest that work-based learning programmes have in the past been common. Consequently, the literature in some countries points to instances where individuals with little formal training have started as members of survey teams and worked their way up to become fully operational geodetic surveyors (United States Department of Labour, 2011). This serves to highlight the significance of a post-primary education that imparts some degree of health and safety training. Nevertheless, a review of literature from the Department of Education and Skills indicates that health and safety is not a standalone subject within the Irish secondary school system (DES, 2011*b*). The Department has, however, recognised the importance of the discipline, and teaching in matters relating to health and safety does permeate a diverse range of subjects across the curricula.

At junior cycle level[60], the Social, Personal and Health Education (SPHE) programme offers tuition in ten diverse modules. As the programme's title suggests, all of these modules correlate to some aspect of psychosocial, physiological or social health promotion. According to the Department, SPHE presents students with a '*unique opportunity to develop the skills and competence to learn about themselves and to care for themselves and others*' (Government of Ireland, 2000*a*). In order to

[60] Junior cycle level (lower secondary education) is a three year programme which is usually taken by students between the ages of 12/13 and 15/16 years.

achieve this, it presents an assorted aggregation of topics (violence and relationship management, road and fire safety, sexual health and substance abuse, mental and emotional self-management, means of self-actualisation, etc.).

Further examples of general safety-related tuition can be seen in the optional Home Economics syllabus (Government of Ireland, 2001), where students are offered holistic tuition in the preservation of personal health relating to domestic life, future work life and various other situations. The broad scope of this syllabus is supported by a specific objective of students '*develop[ing] an awareness of health and safety practices*' in conjunction with an overall aspiration for students to appreciate the significance of safe and hygienic practices through the promotion of the decree that '*safety awareness should be an integral part of life*' (Government of Ireland, 2001).

Concerning the optional technology syllabus, the National Council for Curriculum and Assessment has issued guidelines for teachers that encourage the promotion of health and safety within all design processes, and stress that mandatory constraints relating to safety must be recognised (NCCA, 2006). The curricula in turn reflect this, as one of the general aims of the programmes is to teach students the skills and knowledge needed to create solutions to technological challenges, having taken due cognisance of issues relating to health and safety (Government of Ireland, 2006). In addition, the programmes describe the role of safety officers in the occupational environment and aspects of safety legislation. There is also tuition on the dangers of energy sources and machines, procedures in safety emergencies, efforts to minimise risks, and the use of safety equipment (Government of Ireland, 2006). At Leaving Certificate level, certain elective disciplines such as senior cycle Construction Studies offer teaching in the safety aspects of tools, electricity and onsite behaviour, as well as affording students the opportunity to develop a research project that must take account of safety and ergonomic issues (DES, 2011*c*).

In relation to the science disciplines, the Qualifications, Curriculum and Assessment Policy Unit of the Department of Education and Skills plays a proactive role in promoting safety, owing to the experimental nature of subjects. For example, the Unit distributes advisory publications to schools on issues such as the control of chemicals (Circular 0014/2011) and science teachers' duty to inform students of the hazards pertaining to particular activities (Circular M24/04). The actual science curricula reflect a similar vista. Guidelines for the teaching of Biology stipulate that emphasis must be placed on the promotion of health and safety (DES, 2002). The Chemistry syllabus contains a distinct aim for students to develop the skills needed to conduct laboratory procedures and techniques with due regard for safety (Government of Ireland, 1999*a*). It also promotes the mantra that '*safety should be of major concern*' and stresses both the use and importance of personal protective equipment (PPE). At senior cycle, the syllabus goes so far as to recommend that schools organise a structured visit to a chemical plant, where amongst other things, safety provisions and safety features are clearly addressed with the intention of giving pupils a better understanding of the discipline in a live environment (Government of Ireland, 1999*a*). Finally, the Physics syllabus addresses academic issues such as laboratory safety whilst also conveying practical safety tuition that can be used in everyday life, such as 'e*lectricity safety in the home*' (Government of Ireland, 1999*b*).

Less mainstream subjects also offer opportunities for learning about health and safety. Students opting to take the Leaving Certification Vocational Programme (LCVP) in conjunction with the standard Leaving Certificate are presented with the choice of selecting the link subjects of *Preparation for the World of Work* and *Enterprise Education*. Assessment guidelines for both these subjects illustrate how students as part of the examination criteria are given the option to draft summary reports on health and safety in the world of work (Government of Ireland, 2002).

Students pursuing the more unconventional route of the Leaving Certificate Applied (LCA) also have the potential to be exposed to tuition in health and safety. Distinct modules such as *Work and Living* (module 7) aim to '*raise awareness of health and safety issues in the workplace*' through the provision of classes in areas of fire safety, pregnancy at work, safe use of chemicals, noise exposure limits, visual display unit assessments and safety signage (Government of Ireland, 2000*b*). Although the *Work and Living* module is elective, health and safety does feature strongly in many of the learning outcomes of the other seven modules.

Aside from the aforementioned areas, the only other instance where core subjects indicate aspects of health and safety tuition is within the Business Studies curriculum. Here, health and safety issues pertaining to employer and employee duties are detailed (Government of Ireland, 1996).

At this juncture, it is worth noting that in nearly all of the aforementioned examples, participation is non-obligatory. Students are not required to study Home Economics, Science, Technologies, etc., and instead may opt to sit examinations in subjects which contain no tuition in health and safety. Nevertheless, the structured state curriculum is not the only opportunity for provision of health and safety education in post-primary schools. Similar to the findings from primary level, safety intervention programmes are in operation. From an academic perspective, the literature indicates that such post-primary level interventions have the potential to raise awareness of safety (Reed et al., 2001; Younas et al*.,* 2006) but also are at times found to be unsuccessful (Wright, Rivara and Ferse, 1995).

The HSA adopts the view that intervention programmes do work. At post–Junior Certificate level it offers the *Choose Safety* programme. This initiative lasts twenty hours and comprises six classroom-based modules that aim to address the identification of hazards, the assessment of risk, the implementation of control measures and the nature of accidents. There is also material on the need to accept personal responsibility for safety and the need to communicate with peers about the provision of safety services. The programme is delivered through student workbooks, a teacher guidebook and a DVD. Students' participation involves group work, formalised debating, oral presentation and independent exercises. Students who successfully complete the programme receive a certificate. However, as the programme is steered at a teacher/school level, no recent public data is available on completion rates. Nevertheless, the HSA revealed in 2012 that approximately 10,000 students were participating in the programme each year since rollout (HSA, 2012).

For senior cycle students, the HSA in conjunction with the Galway-based social enterprise company Advance Learning Interactive Systems Online (ALISON) have offered students the opportunity to partake in the online training programme *Get Safe—Work Safe* since July 2009. The course lasts two to three hours and is similar to the *Choose Safety* programme in covering the identification of hazards, the quantification of risks and the implementation of control measures. However, there is also some variance, as *Get Safe—Work Safe* addresses topics such as the reporting of accidents and the legal requirement for safety statements. The most recent statistical data from ALISON reveal that only 10,623 students have engaged with the programme to date (ALISON, 2018).

One possible reason for such a low uptake of *Choose Safety* and the *Get Safe—Work Safe* initiatives may be the fullness of the junior and senior cycle programme in post-primary schools. In support of this theory, the HSA focuses its most comprehensive intervention programme at 4th year students, entitled *Student Safety in the Workplace (Transition Unit)*. This is a 45-hour intervention that incorporates material pertaining to both of the aforementioned initiatives in addition to a more experience-based insight into occupational health and safety. In general, the programme attempts to introduce transition year students to the principles of safety, and to impart skills needed to make autonomous decisions regarding the protection of both themselves and others in an occupational setting. As a result, the initiative correlates to the Department of Education and Science's overall aim for transition year, namely that of '*[promoting] the personal, social, educational and vocational development of pupils and to prepare them for their role as autonomous, participative, and responsible members of society*' (DES, 2011*d*). The initiative itself consists of eight components, with the first six being primarily classroom-based over a 20-hour period. The final sections of the programme, seven and eight, are predominately out-of-class activities (25 hours) and involve experienced-based learning through the student engaging in a work placement. During this time, the student develops a personal reflective diary that must make reference to the provisions for safety in the occupational setting and encourage reflection, analysis and debate on the issues raised.

In relation to uptake, it must first be noted that a significant proportion of students are excluded from partaking in the intervention programme, as not every student elects to enter transition year. Out of those that do enter, HSA figures to date show that on average only 3,416 complete the *Student Safety in the Workplace (Transition Unit)* programme each year (HSA, 2018*b*),

The HSA is not, however, the only external agency offering intervention programmes to post-primary schools. Other agencies such as the Road Safety Authority (RSA) offer junior cycle students educational resources, an example of which can be seen in their *Streetwise Initiative*—an interactive, activity-based resource on road safety. Similarly, at senior cycle level, the RSA facilitates a programme known as *Your Road to Safety for Schools*. However, participation in this programme appears to be low, with the most recent figures showing that by the end of 2012 only 363 post-primary teachers had been trained to teach the programme (RSA, 2012) and no newer published statistics are available as of May 2018.

The National Centre for Technology in Education (NCTE) is another example of an external agency offering intervention initiatives for post-primary students—through their Surfwise *Educational Programme*, an intervention that promotes safe use of the internet (NCTE, 2006).

Aside from the set curriculum and external intervention programmes such as those mentioned previously, schools also have some degree of freedom to implement bespoke safety initiatives. These initiatives can be presented through the use of guest speakers or existing teachers taking on additional duties. However, efforts from existing teachers can have limitations, as research indicates that teachers' competence in matters of occupational health and safety varies significantly (EU-OSHA, 2009), and that those suitably trained in the discipline tend to make better educators of the subject (Jourdan et al., 2008). In recent years the HSA has recognised this quandary and has allocated resources for the continued professional development of post-primary teaching staff (HSA, 2011*c*). It has also sponsored the development of three online learning tools specifically aimed at increasing teacher competence in the discipline of health and safety (ALISON, 2011).

However, it is worth mentioning that significant emphasis has been placed on promoting safety in schools for staff as opposed to teaching safety for students. Evidence of this can be seen in an influential quadripartite publication from the Department of Education and Skills, the State Claims Agency, the School Development Planning Initiative and the HSA entitled *Guidelines on Managing Safety and Health in Post-Primary Schools* (HSA, 2010*a*). The document, which has been distributed to every post-primary school in the Republic of Ireland, seeks for schools to implement safety management systems and provides guidance on best practice concerning such systems. It does not, however, attempt to provide any guidance on the 'teaching' of safety, but instead aims to 'teach the teachers' methods of ensuring their co-workers' and students' safety. The corollary of this sees the teacher's role converted from an educator to a protector when addressing the theme of health and safety.

4.5.1 Conclusion from Post-Primary School Education Review

Although health and safety as a standalone subject remains excluded from the post-primary curriculum, the above synopsis illustrates many instances where aspects of the discipline are integrated into the curriculum. However, in nearly all of the given examples, participation is non-obligatory due to the subjects being elective. Similarly, and owing to resource constraints, many schools offer a restricted number of subjects for students to pursue. This can result in a situation where even if an individual did want to study one of the aforementioned subjects that contain health and safety, it may not be available. The corollary of this is the possibility of some students finishing post-primary education without having been exposed to formalised curriculum-based health and safety education.

The literature also indicates that safety intervention programmes suffer similar coverage problems and do not create equilibrium of education amongst all students. Programmes administered by the HSA and other agencies are not compulsory, and their promotion and facilitation are at the discretion of school management. Statistical data indicates that their uptake has generally been low.

Recent attempts to ensure the continued professional development of teachers are notable; however, there has been a significant emphasis on managing safety in the school environment as opposed to equipping students with the skills needed to manage their own safety in an occupational environment. It is arguable that this may have an adverse effect on those who choose not to pursue higher education and instead enter the workforce.

In summary, and similarly to the findings from the primary level review, it is possible for students to complete six years of secondary education without any, or with only limited, formalised education in occupational health and safety. The combination of these two findings may have a synergistic effect, as EU-OSHA (2010) believes that individuals should come to adulthood possessing an awareness and culture of safety, learned and developed during *youth*. However, in the case of geodetic surveyors who opt not to pursue higher education and whose primary and post-primary education failed to impart this *awareness* and *culture*, their first introduction to formalised health and safety may be gained in an occupational setting, which in itself may be perilous given the correlation between youth and accidents.[61]

For those individuals who do go on to higher education, further opportunity presents for education in the discipline of health and safety prior to entering the workforce.

4.6 Higher-Level Education Review

Individuals who opt to pursue higher education enter programmes that generally have a significant level of autonomy in terms of both focus and syllabus. For geodetic surveyors, the educational path is limited to a number of study opportunities and courses. In terms of quantifying these numbers, a scoping study of higher-level institutions by the author estimated that there are seventy-one courses in the Republic of Ireland providing some degree of tuition in geodetic surveying.[62]

Despite an extensive search, no published literature could be found detailing the amount of health and safety taught on courses in the Republic of Ireland. Given that geodetic surveying is inextricably linked to both engineering and construction (Allan, 1995), there are, however, a limited number of national and international research studies that are of significance. A chronological synopsis now follows.

The Lee Scoping Study 1999

In September 1999, Lee, on behalf of the Health and Safety Executive (UK), carried out a report examining the education of undergraduate engineers in risk concepts. The study attempted to quantify existing educational provisions and carry out

[61] Having carried out wide scale analysis, the European Risk Observatory in 2007 found that young workers aged 15–24 were involved in the highest percentage (16.4%) of workplace accidents across all EU Member States (European Risk Observatory, 2007).
[62] The methodology of which is discussed in Chapter Six.

exploratory research into the desired situation. This was done through structured interviews with a selection of academics, representatives from industry, members of accreditation bodies and consultants.

The study primarily found that graduates do not have sufficient understanding of the concepts of hazard or risk, and that there is ample evidence to suggest the education of engineers in relation to health and safety has not adapted to change. The reasons for this lack of progression were found to be a paucity of confidence on behalf of lecturing staff in the teaching of health and safety, the widespread view that health and safety is not an academic concept, and the fullness of most undergraduate curriculums. In addition, Lee found:

- Lecturers' competence varies in relation to health and safety, and most would welcome more source material and training opportunities.
- Academics believe industry must form a partnership approach to build on the health and safety educational foundation students gain in college.
- The majority of interviewees believe that the current situation can be improved.
- Academics have different views on whether health and safety should be a standalone module or integrated into existing modules.
- Accreditation bodies vary in their awarding criteria requirements for health and safety modules and need to be more consistent.

Lee concluded that health and safety is not universally understood by engineering graduates, teaching competence varies, and provision of more guidance is essential in order to successfully integrate the discipline. To resolve the situation, Lee recommended the formation of working groups—comprising representatives from both industry and academia—while also advocating the development of specific health and safety material for undergraduates by the Health and Safety Executive, and more steering from the professional accreditation bodies.

Having critically reviewed Lee's work, it becomes apparent that the sample population was quite small (n = 35). The report was also solely concerned with undergraduate engineering courses and therefore was quite limited. Lee also pursued structured interviews, leaving little room for flexibility or a more candid debate on possible solutions by stakeholders. The use of focus groups would have overcome this but they were not used. Lee did, however, reference secondary source focus groups such as the *IChem Safety and Loss and Education Party*, whose meetings led to the suggestion that health and safety should be integrated into undergraduates' education at an early stage and comprise a minimum lecturing time of 3–5 hours followed by an examination.

The Symonds Group Ltd Research Report 2001

In 2001, the Symonds Group Ltd consultants, in conjunction with Liverpool John Moores University and the Charlton Smith Partnership, published an investigative report on behalf of the Health and Safety Executive (UK) exploring the extent of health and safety teaching practices in undergraduate construction courses in the United Kingdom. The report took a qualitative approach, using interviews with both students and academics at 31 colleges, and found that the provision of such teaching is in most cases poor. Symonds and colleagues primarily found:

- In many cases, the inclusion of health and safety within the curricula is not supported by heads of departments.
- Health and safety, in general, is not recognised as an intellectual discipline.

- Accreditation bodies' prerequisites for courses vary widely, and most have inadequate requirements in respect to health and safety.
- In many instances, curricula are too full to allow the inclusion of a significant amount of health and safety tuition.
- In the majority of cases where health and safety was included in the curriculum, it was offered as part of a module and not in a standalone capacity.
- The delivery of health and safety material is frequently provided by existing staff, with many not possessing the necessary competence to carry out the role.
- Where health and safety is provided, its study is not always compulsory.

Symonds et al. concluded that although there were some good examples of health and safety education, these were sporadic and that in general most courses address the topic inadequately. The research team also found that health and safety education is of critical importance to students as it forms the base that '*analytical and critical abilities are inculcated enabling currently accepted industry practices to be challenged and reformed*' (Symonds et al., 2001). As a result, Symonds et al. recommended that programmes should be audited with a view to instilling an appropriate element of health and safety into the curricula, and that those partaking in such tuition should be tested on their level of attainment. It was also suggested that professional development courses be provided to staff tasked with teaching health and safety, and that external industry representatives familiar with best practice should be utilised in order to bring a level of real-world experience to courses.

In appraising Symonds and colleagues' findings, it becomes apparent that the scope of research was limited in that it only assessed degree-level programmes. The report does however demonstrate some of the serious flaws in educational programmes at undergraduate level by highlighting diametrical differences in the way health and safety is taught. The authors also adapt a position that academia is not solely to blame, and highlight the importance of creating a synergistic approach through the contribution of industry and accreditation bodies in the provision of guidance.

The Stacey, Simpson and Schleyer Report 2009

In 2009, researchers Stacey, Simpson and Schleyer, working on behalf of the Health and Safety Laboratory (UK) for the Health and Safety Executive (UK), prepared a report examining the integration of risk concepts into undergraduate engineering courses. Primarily they found:

- In most cases, the content of risk education modules is unclear.
- Published literature examining the area of risk education is insufficient.
- It is an arduous task to determine the extent of teaching in risk concepts across third-level institutes.
- Getting all staff to see the benefit of risk education is a complex task.
- Integrating risk education into existing curricula is difficult because of the fullness of most programmes.

To remedy these deficiencies, Stacey, Simpson and Schleyer recommended e-learning packages for lectures, workshops and seminars on health and safety topics, and a web-based depository of health and safety learning aids.

In relation to overall conclusions, Stacey, Simpson and Schleyer's research is not of particular relevance to this review as a significant proportion of their investigations was concerned with implementing an experimental trial at Liverpool University. However, they did conclude with the caveat that except through the use of personal contacts, it is extremely difficult to establish what other higher-level institutes are teaching in regard to health and safety.

The Healy, Kelly, Turner and Townsend: NUIG Report 2011

In 2009–10, consultants Healy, Kelly, Turner and Townsend, in conjunction with the National University of Ireland, Galway, and funded by the HSA and the Institution of Occupational Safety and Health (IOSH)[63], prepared a report examining the inclusion of health and safety within undergraduate construction-related programmes in the Republic of Ireland.

This report illustrated how, historically, Irish graduates enter the workforce with little or no knowledge of health and safety. It took both a quantitative and qualitative approach using electronic surveys and focus groups to establish if this is still the case in the modern educational environment.

Healy and colleagues' findings were triangulated from an aggregate of professional bodies, industry representatives, academics and students, and primarily found:

- There is great inconsistency amongst academics over what level of health and safety tuition is adequate for students.

[63] IOSH is a chartered body for health and safety professionals founded in 1945. With more than 40,000 members in 85 countries, they are the world's largest professional health and safety organisation and a registered charity with international NGO status.

- When health and safety is taught, in most cases it is by academics who are not experts in the discipline.
- The majority of students believe that when health and safety is taught, it is presented by experts in the discipline.
- In relation to examined programmes that did contain tuition in health and safety, the vast majority did not provide it as a standalone module.
- In relation to examined honours degree programmes, on average less than 2% of available ECTS[64] credits were assigned to health and safety.
- 36% of academics surveyed did not know how many modules within their programmes included health and safety as a learning outcome.
- 49% of industry-based respondents felt that their education covered health and safety adequately, while 79% of academics felt that the education they provided to students covered the subject adequately.
- On examined level 7 programmes, ECTS credit value in relation to health and safety was at lowest 0.7 credits and at highest 6.7 credits.
- On examined level 8 programmes, ECTS credit value in relation to health and safety was at lowest 0.6 credits and at highest 30.7 credits.

Healy, Kelly, Turner and Townsend concluded that programmes are being accredited by professional bodies without containing the appropriate quantity of health and safety tuition. Academics, in general, are satisfied with the amount of health and safety education students receive and that the majority of higher-level institutes have attempted to consider health and safety, albeit with varying degrees of quality and consistency. As a result, the authors recommended further training in health and safety for academics—facilitated by the use of DVDs and HSA guidance. The report

[64] European Credit Transfer and Accumulation System.

also encouraged the use of expert guest lectures, and put forth the suggestions that the HSA should develop guidelines for teaching health and safety at higher level and that health and safety should be a specific learning outcome for all programmes.

Although inarguably an insightful report, in appraising Healy and colleagues' work it becomes apparent that its scope was limited to undergraduate degree programmes, thus providing no data from the many certificate, diploma and postgraduate courses students can pursue. Furthermore, only six of the fourteen institutes of technology and five of the seven universities in the Republic of Ireland agreed to participate in the study, leaving it difficult to make inference on overall provisions in relation to health and safety.

In relation to findings, Healy and Townsend claim that great inconsistency exists amongst academics regarding acceptable levels of health and safety tuition for students, which supports the earlier findings from a tripartite seminar held by the European Commission, EU-OSHA and the Spanish presidency, that risk education at higher level is not considered to be an academic concept and that its teaching is often at the behest of individual academics (Bilbao, 2002). Similarly, the finding that health and safety in the majority of cases is taught by academics but not experts in the subject is unsurprising, as the discipline has only been on an all-inclusive legislative footing in Ireland since the introduction of the Safety, Health and Welfare at Work Act 1989 (S.I. No. 7 of 1989).

4.6.1 Safety Intervention Programmes at Higher Level

Unlike the situation at primary and post-primary level, generic safety intervention programmes are not in widespread use. This is mainly due to the vast array of courses on offer at higher level and the difficulty in finding an intervention programme of universal relevance. The HSA has, however, founded a Third Level Initiative Group (TLIG) that has been tasked with exploring opportunities for the inclusion of health and safety in the various curricula and creating awareness of the discipline. In relation to intervention programmes, the TLIG has produced an e-learning course for students on construction-related programmes of study. This course comprises a two-hour self-directed module that may be of relevance to geodetic surveying students. However, statistical data reveals that on average only 575 students have partaken in the initiative each year since its commencement in March 2010 (HSA, 2018*b*).

4.6.2 Conclusion from Higher-Level Review

No previous studies could be found that examine the health and safety content of higher-level courses in geodetic surveying. Investigations from associated areas of study (construction and engineering) highlight great disparity in the teaching of the discipline. However, in relation to geodetic surveying, no definitive conclusions can be formed without further empirical research.

Safety intervention programmes may be used in a higher-level education setting. However, there is no generic programme in use across all institutions; therefore it is difficult to assess the merits and demerits of any such programmes.

No specific safety intervention programme could be found that deals exclusively with the subject of geodetic surveying. The HSA's most comparable intervention is aimed at those studying construction-related programmes and was found to have a limited uptake.

4.7 Private Education Review

Aside from higher-level education, there are an increasing number of privately operated educational courses that individuals may pursue at their discretion. These courses have the potential to broaden understanding in areas of health and safety that higher education may fail to address adequately. In relation to quantifying numbers, literature indicates that in the year 2000, 80 trainers and organisations were offering various courses and educational opportunities in Ireland. By 2009, it was estimated that this figure had risen to some 600 individuals and companies offering courses (*HSR*, 2009).

In relation to quantifying the value of such programmes, Indecon International Economic Consultants, working on behalf of the Irish Department of Enterprise, Trade and Employment, carried out an economic assessment of occupational safety, health and welfare law on the Irish economy in 2006. Their report found that over 82% of those surveyed believed training in occupational health and safety to be either 'somewhat positive' or 'very positive' (Indecon, 2006). With such levels of approval, inference can be made and the point argued that many may find further training opportunities beneficial. Accordingly, one can assume that uptake of such opportunities is considerable. Nevertheless, it is outside the scope of this report to examine the area of private education, as the majority of courses are non-compulsory and no particular programmes could be found that deal exclusively with geodetic surveyors' health and safety.

The only exception to this is presented in the following section of this report, where two compulsory training courses from the construction industry are reviewed. This was deemed appropriate because geodetic surveyors are primarily employed in this industry.

4.8 Safety Awareness Scheme

The enactment of the Safety, Health and Welfare at Work (Construction) Regulations 2001 (S.I. No. 481 of 2001) saw the introduction of the FÁS Safety Awareness Scheme. The Scheme, which is colloquially known as the Safe Pass programme, is a mandatory one-day course and examination on issues of health and safety that all personnel engaged in construction activities must attend and successfully pass.

A revocation and update to the 2001 Regulations in 2006 (S.I. No. 504 of 2006) saw the introduction of a clause (Section 4.3) that excludes certain parties from the requirement to hold a Safe Pass. This faction comprises those working with mechanical, electrical, gas, compressed air, hydraulic, telecommunication and computer systems that are usually domiciled and employed outside the Irish State. This provision has a time limit of 20 working days in any one year, and those availing of the exclusion must be in possession of a letter from their employer stating a description of the proposed work, their competence to undertake it and the proposed start and finish dates. The only other legal proviso for not holding a Safe Pass is if an individual has successfully completed an equivalent safety awareness scheme in another Member State of the European Community that has been approved by FÁS.[65]

The Safe Pass programme comprises the following modules:

- Promoting a Safety Culture
- Duties and Responsibilities at Work

[65] As of 2013, FÁS has been renamed Seirbhísí Oideachais Leanunaigh Agus Scileann (SOLAS) (English translation: continuous skills and education services). For continuity reasons, the former designation *FÁS* will be used in this chapter when discussing legislation enacted prior to 2013 and referenced texts that predate this year.

- Accident Reporting and Prevention
- Working at Heights
- Excavations and Confined Spaces
- Working with Electricity Underground and Overhead Services
- Personal Protective Equipment
- Use of Hand-held Equipment, Tools and Machinery
- Safe Use of Vehicles
- Noise and Vibration
- Manual Handling
- Health and Hygiene.

Nowhere in any of the modules is the discipline of site surveying specifically addressed. This, however, is unsurprising as FÁS (2011*a*) stipulates that the aim of the programme is '*to ensure that all site personnel undergo basic health and safety awareness training*'. Therefore, it can be reasoned that the singling out of any one profession for specific safety instruction is not within the programme's remit.

However, the discipline of surveying has been singled out—albeit in a rather negative context—as there is a 'Frequently Asked Questions' section on the HSA website that self-poses the question '*Who needs to do Safe Pass Awareness Training*?' The Authority's response includes, in addition to the typical workers, a multitude of atypical classes of workers who also require Safe Pass training (on-site security personnel, delivery drivers, students on work placement, etc.). Notably, the response goes on to state that surveyors do not need a Safe Pass (HSA, 2016*b*). The Authority does not provide any rationale for this, but it does state its justification for not placing the requirement on archaeologists, who are similarly excluded, by stating that in the strictest sense of the word, archaeologists '*are not construction workers* *but can, however, spend much of their working day onsite. Therefore it is up to the employer to assess and determine if a Safe Pass is required*'.

These literature findings are perplexing, as site security personnel also do not fall into the category of construction workers, yet they are required to complete the training. Anecdotally, it could be argued that this is a result of the prevalence of construction security personnel fatalities from generator-induced carbon monoxide poisoning (HSA Safety Alert, 2008). If such a claim were proven to be true, it would mean the Authority is prescribing safety requirements reactively as opposed to proactively.

Regardless of the reason, the legislation clearly states that definitive exclusions from the Safe Pass requirement only apply to those factions detailed in the early paragraphs (workers domiciled and employed outside the Irish State) and not to surveyors; however, documentation stemming from the HSA suggests others may also be excluded. Should an employer abide by the recommendations given by the HSA and follow the same advice as that offered on the subject of archaeologists, then inconsistency may be prevalent across the industry. The result of which sees FÁS's (2011*a*) aim of '*[ensuring] that all site personnel undergo basic health and safety awareness training*' becoming defunct and the need for health and safety education becoming even more apparent for the geodetic surveying profession.

4.9 Construction Skills Certification Scheme

Aside from the Safe Pass programme, the 2001 Safety, Health and Welfare at Work (Construction) Regulations also introduced the mandatory FÁS Construction Skills Certification Scheme (CSCS). This initiative differs from the Safe Pass programme as it is specifically targeted at certain trades and occupations. According to FÁS

(2011*b*), the Scheme aims to raise levels of competence by imparting job-specific skills to participants, and includes strong emphasis on issues relating to health and safety. These skills are in areas such as scaffolding, roofing, shot-firing and various classes of machine operation. However, there is no skills training on any aspect of geodetic surveying.

This finding is directly opposite to that in the United Kingdom, where a similar CSCS scheme is in operation that offers skills training for land surveyors (ticket 5468) and chainmen (ticket 5054). As a result, Irish geodetic surveyors are at a disadvantage in terms of compulsory industry-based training, thus serving to emphasise the importance of a formative health and safety education for this profession.

4.10 Chapter Summary and Conclusion

The primary aim of this review was to investigate and critique provisions relating to the health and safety education of geodetic surveyors in the Republic of Ireland using all available literature. This was achieved by examining the legal requirements for health and safety education and the ramifications of failing to abide by such legislative provision. Current efforts from the primary, post-primary and higher-level educational sector were analysed. There was also a review and synthesis of industry-specific training opportunities for geodetic surveyors and sector-specific legislation. Having done this, it was found that:

- There is a legal requirement to train geodetic surveyors in the fundamental aspects of health and safety (S.I. No. 10 of 2005).
- There is practically no legislation that specifies exactly what education a geodetic surveyor must have. This is different to the other surveying

professions such as quantity surveyors or building surveyors (S.I. No. 21 of 2007; S.I. No. 138 of 2008).

- The statutory definition of construction work as per the Safety, Health and Welfare at Work (Construction) Regulations specifically excludes the work of geodetic engineering surveyors.
- Issues of inadequate health and safety training have come before the judiciary on many occasions and have resulted in monetary fines and the awarding of compensation.
- Health and safety is not a standalone subject in the Republic of Ireland's primary or post-primary school curricula, and there are no guarantees that a pupil will receive any formalised education in the discipline at these levels.
- Because of the vast number of higher-level courses available, it is not possible to comment collectively on the health and safety content. In relation to geodetic surveying courses, the body of research does not indicate any past investigations examining the quantity or quality of health and safety taught to students.
- In the most closely related higher-level disciplines (construction and engineering), evidence suggests great disparity in the teaching of health and safety.
- Conflicting advice exists between legislators and the Health and Safety Authority in relation to whether a geodetic surveyor is required to hold the most basic training—that is, Safe Pass.
- Construction Skills Certification Scheme (CSCS) training is not available to geodetic surveyors in the Republic of Ireland, whereas in the UK the scheme is offered to both surveyors and their chainmen.

These findings demonstrate that the issue of health and safety training and education is of serious concern and that the occupation of geodetic surveying has been overlooked in terms of legislation.

Evidence also suggests that early and middle education in the Republic of Ireland is challenged in its provision of formative health and safety teaching. Compulsory industry-specific training is also failing to address adequately the issue of geodetic surveying. This leaves the area of higher-level education as the principal provider for such tuition. However, to date, there has been no systematic review of efforts from this sector. This leads to a strong argument for further investigative research on the extent of health and safety taught to geodetic surveying students in higher-level institutions, as a clear gap is evident in the published body of research.

A reader unaccustomed to the hazards of surveying may ask why such an investigation is needed, as undoubtedly there are other equally important professions that employ greater numbers and suffer a similar scarcity of investigative research. The riposte to this lies in the fact that surveying has multiple intrinsic hazards that have the potential to negatively affect occupational health and safety. Support for such a declaration is found having carried out a case study, the details of which are discussed in the following chapter.

CHAPTER FIVE

The Occupational Hazards of Geodetic Engineering Surveying:

An Irish Case Study

5.1 Introduction

A hazard is anything with the potential to cause harm. Such sources of danger appear in every place of work and can be naturally occurring or manmade. In the majority of cases, hazards are classified as dormant or active and may be assigned a risk factor ranging from negligible to severe. The profession of a geodetic engineering surveyor is no different than any other as regards the presence of these hazards; the profession is however different with respect to the type of hazards that are present. As outlined in earlier chapters, a surveyor is someone who is integral to the entire construction process and as a consequence operates in a sector of work that is recognised for its ever-transient environment, diverse workforce, complex machinery, atypical working hours and hazardous substances. In addition to these customary dangers, there are also hazards that a surveyor may bring to the construction process or generate through their responsibilities onsite.

A case study is the name given to '*empirical research that investigates a contemporary phenomenon within its real-life context*' (Yin, 2003). In essence, it is a means of exploring a research subject by examining a chosen group that make up part of a larger population. The case study model is not used to make inference about the entire population but instead is helpful in expanding theory on select subsets. As a result, a well-constructed case study can illuminate what is occurring and why, when and where it is happening.

In view of this, a case study approach has been chosen as the medium for investigating this chapter's principal aim and central question: *what are the hazards of geodetic engineering surveying?*

This method is the most suited mode of research for this type of study as it can enable the collection of a complete variety of evidence in the form of documentation, interviews and on-site observations. For this reason it has been considered attractive, as suspected findings will be too complex for other research methods such as surveys or semi-structured interviews. In addition, the latter would rely on the competence and perceptiveness of the individual being examined to identify, acknowledge and articulate the hazards that they encounter. And as the hypothesis of this thesis has put forth the suggestion that surveyors are exposed to inadequate levels of health and safety tuition, this would be ill-advised.

Following explanation of the adapted methodological framework, the remainder of this chapter will report on the results of enquiry from a ten-day case study conducted on an Irish construction project in 2011 that employed two surveyors and one assistant part-time surveyor.

5.2 Case Study Approach

In order to accurately identify the hazards, the development of a hierarchical task analysis (HTA) was considered. This is a process of systematically examining and deconstructing all performed tasks through the use of a diagrammatic representation. Its purpose, according to Annett and Stanton (2000), is to '*understand what people are doing, how they can fail, and how such failures may be prevented*'. As this study aims to identify hazards, it meets Annett and Stanton's primary criterion of '*understand[ing] what people are doing*', as this must first be determined in order to ensure that possible hazards can be identified for every task. However, Annett and Stanton's second criterion of '*how they [one] can fail*' is of little interest to this study, as failure in any of the envisaged tasks will lead to erroneous surveys that although detrimental to a project's success, have no bearing on the surveyors' occupational wellbeing. Even if one were to theorise that a *hazard* is akin to a *failure* and conduct a HTA, this would be an illogical pursuit as hazards can never be entirely removed from a workplace but failures can. Analogous to this is the unsuitability of Annett and Stanton's final criterion that seeks to establish '*how such failure can be prevented*'. This is unsuitable because this study aims to create a comprehensive listing of 'what are the hazards of geodetic engineering surveying?' but does not attempt to suggest remedies of correction. Such an approach is diametrically opposed to Annett and Stanton's view[66] of the purpose of a HTA, as they believe it should provide '*a diagnosis and a proposed cure, not just a list of symptoms*'.

As a result of this and the aforementioned line of reasoning it was decided not to use the HTA research tool. However, the value of a task analysis still remains and is suited to this study as it refers to a generic method of analysing each undertaking in terms of the action or cognitive process that is needed to achieve a desired state or overall goal. In view of this, each of the tasks the surveyors performed were recorded, analysed, and described. In order to bring structure to the report, a simple yet effective sequential ordering system has been used. The combination of analysis and chronological ordering makes for a sequential task analysis (STA). Whittingham (2004) defines this as a '*method of representing a sequence of tasks in the order in which they take place*'.

In total, three primary tasks were analysed in this manner: establishing land made available, setting out, and levelling. Contained in these three tasks were fifteen

[66] The author of this study justifies placing such emphasis on Annett and Stanton's opinions as to how a HTA should be conducted, as it was Annett in conjunction with Durcan who first proposed the concept of hierarchical task analysis. See Annett, J. and Duncan, K. (1967). 'Task Analysis and Training Design', *Occupational Psychology* 41, pp. 211–221 for further information.

subtasks. Using observation and professional experience[67] the author identified twenty-three hazards from these subtasks that had the potential to negatively affect the surveyors' occupational health and safety (See Table 1.3 below).

Table 1.3 Sequential Task Analysis

TASK 1: ESTABLISHING LAND MADE AVAILABLE (LMA)	**ASSOCIATED HAZARDS (H)**
1. The surveyor determines what areas of LMA must be established before arriving at the works location	None identified
2. The surveyor arrives on site and commences the process of establishing LMA	**(H.1A)** A surveyor carries all the equipment necessary for establishing LMA **(H.1B)** The surveyor works alone **(H.1C)** The surveyor walks long distances and stands for lengthy periods of time **(H.1D)** The surveyor interacts with the surrounding environment **(H.1E)** The surveyor seeks welfare and sanitation services
3. The surveyor uses surveying instrumentation to set out LMA	**(H.1F)** GPS equipment is used
4. The surveyor denotes the established co-ordinates	**(H.1G)** Vegetation is cleared **(H.1H)** Stakes are hammered into the ground
5. The denoted positioned is highlighted	**(H.1I)** Spray paint is used
Task 1 is now complete	
TASK 2: SETTING OUT	**ASSOCIATED HAZARDS (H)**
1. The surveyor determines what areas of a site must be set out	None identified
2. Essential equipment is prepared	**(H.2A)** The surveyor cuts pins needed for setting out
3. Pins are loaded into a vehicle	None identified (Due to task being performed by a general operative)
4. The surveyor drives to the location where setting	**(H.2B)** The carriage of surveying pins

[67] The author is qualified in the discipline of higher-level health and safety, has fourteen years' experience working in a health and safety managerial role on construction projects with a total value in excess of €1.4 billion, lectures at university level in construction safety, and is familiar with the main hazards that trigger accidents.

out work is planned	
5. The surveyor sets up a total station instrument	**(H.2C)** The surveyor uses a total station instrument **(H.2D)** The surveyor works near traffic
6. Control points are set out	**(H.2E)** Control points are hammered into place
7. Pins are set out	**(H.2F)** The surveyor works near plant and machinery **(H.2G)** Pins are hammered into place **(H.2H)** The surveyor uses a digging bar **(H.2I)** Projecting rebar becomes evident
Task 2 is now complete	
TASK 3: LEVELLING	**ASSOCIATED HAZARDS (H)**
1. The surveyor determines what pins must be levelled	None identified
2. The surveyor uses a dumpy level	**(H.3A)** Anatomical misalignment while using a dumpy level **(H.3B)** A second surveyor uses a measuring staff. Manholes are dipped **(H.3C)** Measurements are taken in excavations **(H.3D)** Work at heights is performed
3. The surveyor generates hazards for other parties working on site	**(H.3E)** Grading teams are forced to pull string lines and take dip levels
Task 3 is now complete	

5.3 Establishing Land Made Available (Task 1)

Most construction projects start with a surveying team establishing land made available (LMA). This is the process of using survey instrumentation to mark the boundaries of a construction project and delineating these boundaries with wooden stakes or other suitable indicators. In turn, this allows for the subsequent installation of perimeter fencing or hoarding and ensures that construction work does not encroach on areas outside the project’s scope. This can be an extremely hazardous undertaking, especially if the project is a green field site, the surveyor is the only person at the location, or the works are based over substantial areas. Having conducted the STA, the following hazards were deemed to be associated with this particular task:

5.3.1 Associated Hazard 1A: Carrying equipment for establishing LMA

Surveyors use a vast array of equipment while setting out LMA. When vehicle access is not available, wooden posts, aerosol canisters of paint, sledgehammers, GPS units, cutting equipment, an assortment of personal protective equipment (PPE), two-way radio transceivers, peg books and associated paraphernalia must be manually transported.

Research conducted by the US Army into the job profile of topographic military surveyors—a related discipline to geodetic engineering surveying that looks to examine the location of natural and manmade features of the earth's landscape—has led to the occupation being assigned a physical demand rating of *moderately heavy* (DOA Pamphlet 611–21, 2008). Under military regulation this dictates that such operatives will be required to lift on an occasional basis a maximum of 80 lb (36 kg), with frequent or constant lifting of 40 lb (18 kg). However, the typical equipment the geodetic surveyors carried each day in this case study (See Figure 1.8 overleaf) weighed 59 lb (27 kg).[68] This may be considered precarious due to the correlation between occupational-related injuries and musculoskeletal damage.[69]

[68] The assessment was conducted using a calibrated AE Adam 401 pallet weighing scale.

[69] Incident statistics from the Health and Safety Authority's *Summary of Workplace Injury, Illness and Fatality Statistics 2013–2014* (2015) illustrate that manual handling tasks are the most common cause of accidents, making up approximately one-third of all reported injuries. Comparable annual reports from as far back as 2003–2004 indicate that this statistic has remained relatively consistent. In the Irish construction industry, by 2009 the problem was severe enough for the HSA to seek outside assistance from the Health and Safety Laboratory (a subsidiary of the UK Health and Safety Executive), who developed a report entitled *Manual handling in the Irish Construction Industry, ERG/09/09* that highlighted numerous systemic high-risk activities indicative of the sector. As a result of the seriousness of the problem, the European Commission has stated that occupational-derived musculoskeletal injuries are of concern and will be given priority (European Commission, 2007).

Fig. 1.8 *Calculating the Weight of Surveying Equipment to Establish LMA*

5.3.2 Associated Hazard 1B: Lone working

The Health and Safety Authority defines lone workers as those who '*work by themselves without close or direct supervision*' (HSA, 2011*e*). As a surveyor is often the first on site, this form of work regularly takes place. Consequently, the associated hazards are abundant, with research indicating that lone working in the construction industry is a high-risk activity (Bryan, 2010). However, despite their abundance, the accurate identification of such hazards is difficult for two reasons: firstly, on commencement of a construction project the only knowledge of a site is usually from maps and information derived from designers. This leaves the surveyor dependent on a faction that may or may not have adequately considered their health and safety.[70]

[70] In recent years, Irish legislation has placed a greater onus on construction designers to devise projects with an improved consideration of safety. Nevertheless, Lingard and Rowlinson (2005) articulate that despite the best intentions of legislators and regulatory bodies, in reality most hazard identification is still done on site.

And secondly, to quantify the hazards of lone working one must consider a diverse aggregate of situations that range from the inadequate provision of first aid to psychological factors relating to isolation. This makes it difficult to gauge all prospective hazards whilst still maintaining a level of practicality in an assessment.

Fact

During 2001–2002, the HSA visited 204 construction designers' offices and conducted a survey to determine their extent of health and safety knowledge. Findings revealed that the majority of designers had a poor understanding of the discipline and only 10% had any health and safety qualifications (HSA, 2003). A more recent study that this author was involved in (Kearns, O'Hara and Kelly, 2010) highlighted that 87% of safety personnel from Irish construction companies still believe that designers are not giving adequate consideration to those involved in the construction process.

As this study was conducted at the early stages of the construction process, when only design-based information was available, difficulty was encountered in adequately determining the hazards of lone working for this profession. However, because surveyors are tasked with the division of lands, the prospect of violence is undoubtedly of paramount concern. Further credence can be added to this assertion when one considers the strong correlation (HSE, 2002; HSA, 2007*b*; EU-OSHA, 2010) between lone working and such aggression. As a result, the paradox of such social isolation can create the social problem of occupational violence, which Barnard (1998) has stated is a specific problem for those engaged in this profession.

Concerning this particular study, the surveyors spent a significant duration of time working alone, with *Surveyor A* spending 40–50% of each 10-hour working day unaccompanied[71] and *Surveyor B* spending 10–80%.[72]

[71] Calculations were based over a 5-day (50-hour) reference period in week one of observation.
[72] Calculations were based over a 5-day (50-hour) reference period in week two of observation.

The Loneliness of a Long Distance Surveyor © Kearns, 2012

5.3.3 Associated Hazard 1C: Prolonged periods of walking and standing

Research suggests that during surveying operations it is common for a geodetic engineering surveyor to walk long distances and stand for long periods of time (Echaore-McDavid and McDavid, 2007). In relation to walking, such physical exertion may be hazardous from an anatomical perspective if it overtaxes the surveyor and leads to an exhaustive state, while the negative effects of prolonged standing have been well documented (Tomei et al., 1999; Flore et al., 2004; Sudoł-Szopińska et al., 2011).Through the use of a pedometer (See Figure 1.9 overleaf) it was established that the surveyors in this study walked an average of 6 km a day.[73] From a hazard assessment perspective it should be noted that walking in a construction site environment has associated risk factors in the form of slips, trips

[73] The assessments were conducted using an Omron model pedometer. The device was checked for calibration accuracy on site by performing simple pre-trial step tests. The actual assessments were conducted over a 10-day period, during which time *Surveyor A* wore the device for 5 days (week one) and *Surveyor B* wore the device on another 5 days (week two). The mean score was then computed and the average daily walking distance was calculated.

and falls. During the observation period of this case study no such incidents or accidents were observed; however, the surveyors did affirm that slips, trips and falls were a familiar occurrence in their occupation. Such an assertion, although unproven in this case study, does seem plausible when one considers the presence of rough terrain, steeply graded land and various other influencing features.

Attempts to quantify periods of standing were not made, but it is worth mentioning that considerable time was spent engaged in a static position, especially when holding telescopic measuring staffs and other such instrumentation.[74]

Fig. 1.9 *Calculating the Distance a Surveyor Walks Using a Pedometer* © Kearns, 2012

[74] These items are discussed in greater detail in the latter parts of this chapter.

5.3.4 Associated Hazard 1D: Environmental interaction

Given that the majority of geodetic surveying operation takes place outdoors, there are numerous environmental factors to consider. In Ireland, average wind speed varies from as low as 11 km per hour in parts of Leinster to more than 28 km per hour in parts of Ulster. Annual wet days (days with 1 mm or more of rain) average between 150 per year on the south-east coast to as many as 225 per year on the west coast. Hours of sunshine typically range from 1100 to 1600 per year. Air temperature falls below zero on about 40 days per year and normally reaches 18–20°C during summer months (Irish Meteorological Service, 2011). Given such polarity and fluctuations in levels of wind, rain, sun, and air temperature, the occupational health of a surveyor can be put at risk. During the test period of this case study it rained repeatedly and was moderately cold (10°C on average).

> **Fact**
>
> Such is the prevalence of threatening animals for surveyors in some American States, government publications advocate the carrying of *a pointed lath* by the profession to ward off attacking animals (Washington State Department of Transport, 2005).

Apart from direct environmental effects, there are also other features of the environment that may be hazardous to surveyors. Work in rural areas can be testing for them as they are often forced to encroach on animal habitat. At the lower end of the spectrum this can result in insect bites and stings, while at the higher end hostile agricultural animals may be encountered.[75] Natural features of the Irish countryside also provide challenges for the profession, with nettles and briars at worst being a discomfort and the traversing of bogs, marshes and rivers being regarded as significantly more perilous.

[75] Figures from the Health and Safety Authority for the period 2000–2009 reveal that there were 24 deaths due to livestock. Of these, 62% [15] were from bull attacks (HSA, 2011*f*).

During the course of this research no noteworthy interactions were observed; however, the surveyors were challenged by aggressive dogs on the third day of observation.

5.3.5 Associated Hazard 1E: Lack of welfare and sanitation facilities

Although the provision of welfare and sanitation facilities for construction sites is mandatory under Irish law, they must first be established. In the majority of cases this involves the locating and connecting of water, sewerage and electricity, coupled with the delivery and installation of service-equipped containers. When this is successfully achieved, it is customary to position such facilities in the primary compound area of a construction site. However, as discussed in this report's preamble, the purpose of determining LMA is to locate the outline footprint of the construction project, ergo in the majority of instances surveyors must first have LMA established before even basic services akin to a site compound can be constructed. As a consequence, the profession can be left without the use of the aforementioned facilities for considerable periods of time. The ramifications of this may range from a lack of shelter in times of inclement weather to an increased possibility of contracting Weil's disease (Leptospirosis) or other such biological diseases.

In this case study, the connection of facilities took three days from the date of project commencement. During this time the surveyors were constantly onsite.

5.3.6 Associated Hazard 1F: Using GPS surveying equipment

In relatively recent times, surveying instrumentation has incorporated Global Positioning Satellite technology (GPS) in order to expedite the survey process.

In this study, two GPS surveying units were used: an older, backpack-based system and a more contemporary Bluetooth®-equipped model. Both units performed the same function, and from a hazard identification perspective both units, under normal parameters of use, were found to be relatively safe. This assertion can be made having examined the products themselves, related safety documentation and their use in the occupational environment. However, there are certain caveats that should be noted:

- Both types of GPS units contain an auxiliary pointed antenna that presents a risk of ocular injury.
- On the backpack model the power cords contain lead. This metal has a high toxicity value and is known to have nephrotoxic and teratogenic properties.
- The GPS receiver emits radio frequency waves (RF). As a result, the user should not come within 25 cm of the radio modem, as any distance closer than this may result in excessive exposure.
- Batteries belonging to GPS units, depending on use and weather conditions, must be charged daily. During the charge period the battery transformers can become significantly heated and create a risk of fire if they are covered by an obstructing material or substance that does not allow heat to dissipate sufficiently. The charging of batteries also requires connection to a 220V electricity socket; however, best practice in the construction industry suggests that only 110V power should be used onsite. As compound facilities can be

extremely limited during the establishment of LMA (See *Associated Hazard 1E*), this can be a challenging demand.

Despite the aforementioned risks, no unsafe incidents materialised during the observation period of this case study.

A Surveyor and her GPS Unit © Kearns, 2012

5.3.7 Associated Hazard 1G: Clearing vegetation

In an age when green practices on site are favourable, attempts are often made to keep a project's ecological footprint as small as possible. For this reason the large-scale site clearance of trees and vegetation is rarely done before exact LMA co-ordinates are established. As a consequence, a surveyor must often use a handsaw to cut their way through significant amounts of obstructing material to allow co-ordinates to be found and indicating markers positioned. During the observation period of this study, a considerable quantity of such material was removed (See Figure 2.0 below). This was done without incident or accident. However, the use of an unguarded serrated blade should be regarded as an occupational hazard. Similarly, as the surveyors did not wear eye protection when entering areas of dense vegetation, the risk of ocular injuries from protruding branches became apparent.

Fig. 2.0 *A Surveyor Clearing Vegetation* © Kearns, 2012

5.3.8 Associated Hazard 1H: Hammering stakes

In order to establish LMA, surveyors must denote the determined co-ordinates with wooden stakes or other suitable indicators. On this particular project, 600 mm pointed wooden stakes were used. They were hammered into the ground using a 15 lb sledge. The associated risk was postulated to be the operator striking themselves with the hammer. Naturally this risk was deemed to increase with the number of times a post needed to be struck. As LMA was not required for architectural accuracy, the stakes were driven by one person, thus ruling out injury to a second party. However, due to their shortness in dimension it was necessary to hammer the posts very low into the ground (See Figure 2.1 below), which in turn created a particular risk of strikes to the lower limbs of the operative. Despite this evident risk, no such incidents were observed, although it should be stated that very few stakes were hammered during the observation period of the study.

Fig. 2.1 *A Surveyor Hammering Posts* © Kearns, 2012

5.3.9 Associated Hazard 1I: Spray painting using an aerosol canister

Surveyors use spray paint to mark services, stakes, pins and control points (See Figure 2.2 on page 107. This paint comes in the form of aerosol canisters that deploy via a two-finger-operated nozzle. The product's safety data sheet (SDS) confirms that the associated risks are that it is highly flammable (R11), harmful if inhaled and injurious upon contact with skin (R20/21). To combat these risks the SDS lists five advisory safety phrases, namely: keep away from sources of ignition (S16); avoid contact with skin (S24); avoid contact with eyes (S25); do not empty into drains (S29); and take precautionary measures against static discharges (S33).

In relation to personal protective equipment (PPE), users are directed to wear safety glasses and protective clothing, and to use a respirator if vapours accumulate. Toxicological information also highlights that the acute effects of inhalation can include irritation of the respiratory tract and possible drowsiness, while physical contact to the eye can result in severe irritation. In addition, the acute effects of skin contact may result in moderate irritation and drying.

The more serious chronic effects of exposure are also detailed in the product's SDS: prolonged inhalation can affect the central nervous system and asphyxiate the user, while repeated skin exposure may lead to dermatitis. Furthermore, the product does have ecotoxic properties.

It is also noteworthy that the opening sections of the data sheet convey that the method of application for this product should be '*through a hand operated line marking trolley*' and not by the widely used two-finger-operated nozzle technique.

During the observation period on site, six tins were used. At no time was eye protective equipment worn. The surveyors did take caution to discharge the canisters with their back to the wind so that dispersion occurred outward from their bodies; however, on occasion, sudden wind variations resulted in the spray blowing back onto the surveyor's face. Respiratory protection was also not worn.

Fig. 2.2 *A Surveyor Deploying Spray Paint* © *Kearns, 2012*

5.4 Setting Out (Task 2)

As part of their role on a construction project, surveyors must set out the location of proposed works in order to enable construction development. This process involves the surveyor 'laying out' the geometry of the project with the aid of steel pins and other markers. The main objective of the undertaking is to guide the workers by defining in plan and elevation the location of proposed works so that construction can be delivered true to the design specification. As setting out is essentially the transferral of detail from a design map onto the actual ground, instrumentation such as GPS units and total stations[76] are used. Although the former greatly expedites the survey process, the latter is still used for high-precision accuracy. In this study both instruments were used at alternate times.

[76] A total station instrument is an electronic theodolite and an electronic distance measurement device that enables the calculation of horizontal and vertical angles as well as horizontal and vertical distance through the use of a central processor with an electronic recording capability.

Having conducted the STA, the following hazards were deemed to be associated with the task of setting out:

5.4.1 Associated Hazard 2A: Cutting pins

The surveyors were observed cutting pins with a cut-off saw (also known as a con saw) on day eight of this study (See Figure 2.3 overleaf). Subsequent investigation revealed that they had no formal training in the use of this machine. Nevertheless, it was stated that this was an exceptional occurrence and that typically surveyors do not cut their own pins (this task is performed by general site operatives).

Regardless of the frequency of occurrence, untrained use of this machine is in contravention of Irish abrasive wheel legislation (Safety, Health and Welfare at Work (General Application) (Amendment) Regulations 2016 (S.I. No. 36 of 2016) and the relevant sections on *training* in the Safety, Health and Welfare at Work Act S.I. No. 10 of 2005, coupled with the subsequent regulations it invokes and can be regarded as significantly hazardous, since the use of such machines presents the associated risks of fire, vibration, fume inhalation, entanglement, hearing damage, eye or body injury and disc disintegration.[77]

Despite the aforementioned risks, no incidents or accidents materialised during the observation period of this study.

[77] When cutting pins, a composite blade must be used. For other cutting operations such as concrete, a diamond-tipped blade is necessary. Both types of blade are interchangeable on a handheld cut-off saw and are similar in dimension and weight. As a result, an untrained operator may easily select the wrong one. Should this happen and the saw be used, the blade can disintegrate and eject flying particles at an extremely high speed.

Fig. 2.3 *Cutting Surveying Pins* © Kearns, 2012

5.4.2 Associated Hazard 2B: The carriage of surveying pins

Surveyors are commonly required to transport the stocks of pins they intend to use to various locations throughout a construction site. This is predominantly done through the use of vans and commercial four-wheel drive vehicles, with the pins being stored in the rear compartments. Should these compartments not be segregated with either a partitioning screen or cage, there is potential for the pins to become displaced during carriage, come forward into the front of the vehicle and cause injury to the driver or passenger. As the surveyors must often traverse extremely rough site terrain, this is a significant risk.

The vehicles used by the surveyors in this case study were not equipped with a means of segregating the rear compartments, and although no injuries occurred, the pins did come forward into the front of the vehicle during an instance of heavy braking on one day of observation.

5.4.3 Associated Hazard 2C: Using a total station instrument

On this project, setting-out works were done using a total station instrument (See Figure 2.4 on page 112) in conjunction with GPS-enabled equipment. The risks of using the latter have already been discussed in *Associated Hazard 1F*; however, the use of a total station instrument in an occupational environment presents dissimilar challenges.

To begin with, the instrument is heavy (6.6 kg) and cumbersome, yet extremely sensitive and easily damaged. The most severe risk associated with its operation is probably that of eye injuries. This is because the instrument can emit both a visible and invisible laser beam depending on the selected mode of operation. The instrument also contains a telescopic lens that if aimed in the direction of the sun can cause ocular phototraumatism due to its magnifying proprieties. One would presume that no competent professional would do this; however, a surveyor must often sight targets on hilltops, bridges, rooftops and other such elevated positions which as a consequence may force them to aim their instruments on an upward trajectory that is often in the direction of the sun.

Having examined the instrument, associated safety documentation and its use in the occupational environment, there are certain other caveats that should also be noted:

- The instrument must be mounted on a tripod. As a result, care must be taken not to allow it to fall while performing this operation, as damage to the feet of the surveyor can occur as a consequence of the instrument's weight. The tripod legs can also present a trip hazard when fully extended. This hazard may become even more probable when the equipment is set up in public areas of high pedestrian footfall.

- The instrument's carrying case weighs 4.5 kg. If both back straps are not used or are incorrectly adjusted or damaged, the carrier can experience discomfort and possible musculoskeletal injury as a result of the physical strain. This risk increases when the instrument is placed inside the case, as the weight subsequently increases to 10.3 kg.
- There is a risk of fire or electric shock if the instrument is disassembled or repaired by an untrained individual.
- There is a risk of fire or electric shock if power cables are used when damaged. Due to the physical nature of construction work, such damage is foreseeable.
- There is a risk of fire or explosion if the instrument is used in certain environments, as it is not intrinsically safe.
- Similarly to GPS units, a total station uses a rechargeable battery-pack to power its operation. When carrying out this recharging, battery transformers can become significantly heated and present a risk of fire if they are covered by an obstructing material that does not allow heat to dissipate sufficiently. The particular type of battery used in this instrument was Lithium-ion. It is dangerous if opened or mishandled, and inappropriate disposal can result in an ecological hazard.

Despite the aforementioned risks, no incidents or accidents occurred whilst using the total station instrument during the course of this investigation. However, on detailed examination of the device it became apparent that the laser warning decal had been worn away from its required location[78] and was no longer visible (Such warning decals are required under EU legislation). As a result, when the device is used in invisible laser mode, those in the working vicinity have no perceptible warning.

Fig. 2.4 *The Total Station Instrument* © Kearns, 2012

5.4.4 Associated Hazard 2D: Working near traffic

On civil construction projects a surveyor must often work adjacent to live roads, as new developments regularly stem from existing carriageways. This means an increased risk of being struck by passing vehicles. Scallan et al. (2004) report that motor vehicle traffic accidents are the foremost cause of *unintentional injury death* in the Republic of Ireland. The Road Safety Authority (2018) draws attention to the fact that in 2017 there were 158 people killed on the country's roads. The number of non-fatal and work-related traffic accidents is, however, much more difficult to

[78] The decal should be positioned over the beam aperture.

ascertain. This is mainly due to the limitations in data collection systems.[79] However, it is reasonable to assert that the number is significant.

In this study, it was found that in the majority of instances the surveyors attempted to stay behind Varioguard protection systems.[80] This made the hazard more tolerable as the surveyors were afforded a higher degree of safety than if the guard had not been there. However, work dictated—it must be said through design flaws—that at times they were forced to work in areas not protected by the guarding system (See Figure 2.5 overleaf). This saw the surveyor operate in close, unguarded proximity to live traffic. Visual estimates place the minimum distance of passing vehicles at 10 feet (3 metres).[81] Attempts were made to quantify the volume and speed of the passing vehicles. Ten surveys of one-hour duration were conducted over ten days to estimate the volume of daily traffic (between the hours of 08.00 and 18.00).[82] On average, 220 vehicles per hour passed the location of works.

On this project, signage was erected for the public indicating that a temporary speed limit of 50 kph when passing the works was in place. Although means of accurately calculating passing vehicle speed were unobtainable, site limits appeared, in general, to be ignored by members of the public. As a result of this and the aforementioned volume of traffic, working in this environment was deemed to be a considerable occupational hazard for the profession.

[79] See Drummond (2007) for a thorough analysis of the subject.

[80] Varioguard® is a certified (EN 1317-2) energy-absorbing temporary crash barrier that is produced in a galvanised grey steel finish of various interconnecting lengths. Typically it is erected to run parallel to a site and ensures that public vehicles are segregated from site works.

[81] More scientific means of calculation were not possible as it was deemed too dangerous.

[82] The survey was conducted from a stationary vehicle located at midpoint on the site. A handheld mechanical clicker unit was used to ensure the tally was accurately recorded. The total number of passing vehicles was 2,039. A statistical outlier during hour 4 (Day four) was recorded due to a stop/go flag system in operation that severely disrupted traffic. This was subsequently dismissed from the collated figures.

Fig. 2.5 *Surveying in a Live Traffic Environment* © Kearns, 2012

5.4.5 Associated Hazard 2E: Establishing control points

It is necessary for a surveyor to create control points at the initial stage of a survey. These are exact benchmarks where co-ordinates and levels (position and height) are known. Such points need to be made in an immovable object in order to ensure precision survey accuracy from the outset. In order to achieve this, surveyors typically hammer a nail into a footpath and denote the location with a triangular mark (See Figure 2.6 on page 116). Footpaths make a good choice for such points as they are extremely stationary and do not have heavy objects traversing over them (pedestrian footfall is usually too light to move a well-positioned benchmark). A nail into the top of a short stake that is then driven into the ground can also be used; however, this form of control point is more likely to move due to soil shift, the presence of plant and machinery, or indeed the curiosity of members of the public.

In this study, the survey team chose the option of hammering masonry nails into the footpath's concrete. As a consequence, the risk of eye injury became apparent especially when the dense strength of concrete and the force needed to get a nail to penetrate were considered.[83] In assessing the risk of eye injury from hammering nails, of commensurate concern is the prevalence at which eye injuries of this nature occur, the effect they can have on the injured party's quality of life, and the severity with which they influence overall occupational output in Ireland.[84] However, despite these risks, during the observation period of this study the surveyors did not wear eye protection.

In addition, the task of establishing control points presents the risk of injury to the hand. This is because the operative when attempting to strike the nail head with a hammer must hold the body of the nail with their free hand in order to keep it steady. Despite this risk the operatives did not wear any personal protective equipment in the form of impact-resistant gloves.

Although the risks of eye and hand injuries are closely associated with this task, during the course of this investigation no incidents or accidents were observed. However, on numerous occasions nails were observed bending under the force of the hammer strikes and expelling from the concrete at a high velocity.

[83] Nails must be made flush with the pavement so that they do not create a trip hazard for pedestrians.
[84] A review of eye injuries treated by doctors in an Irish hospital's ophthalmological department from 2001 to 2007, carried out by Saeed and Beatty, revealed that almost one third were caused by occupational accidents (*HSR*, 2008). A 2010 report by Deloitte Access Economics on vision impairment and blindness in the Republic of Ireland cited figures that estimated the financial cost to be €386 million in 2010. From an occupational perspective, productivity losses were assumed to be €56 million for the comparable year while predictions for the year 2020 suggest it may be as high as €63 million (NCBI, 2011).

Fig. 2.6 *Establishing Survey Control Points* © Kearns, 2012

5.4.6 Associated Hazard 2F: Working near plant and machinery

Plant and machinery is a ubiquitous feature of the construction landscape. In recent years a demand for bigger, faster and more powerful equipment has led to the development of greater efficiency and productivity in construction machinery. Much of this development is 'operator centred' and commonly overlooks the challenges ground workers face while trying to work together safely on a construction project. The Health and Safety Authority corroborates this assertion through statistical data, as the last nine publications of its annual *Summary of Injury, Illness and Fatality Statistics* emphasise a total of thirty-nine machinery/plant-related fatalities in this sector (HSA collation, 2018). The surveyors on this project were observed working in proximity to large items of plant on numerous occasions (See Figure 2.7 overleaf). Although this is undoubtedly a high-risk activity, no accidents or incidents materialised.

Fig. 2.7 *Surveying in the Vicinity of Construction Plant* © Kearns, 2012

5.4.7 Associated Hazard 2G: Hammering pins

Following the setting out of co-ordinates, a surveyor is required to denote the established position with steel pins. This is necessary as wooden stakes do not provide a sufficient degree of accuracy. As these pins must be hammered firmly into the ground, strikes to underground services are of major concern. The consequence of penetrating underground cables or conductor insulation can result in explosive electrical arcing and fire. According to the Health and Safety Authority (2010*b*), this can give rise to '*severe and potentially fatal burns to the hands, face and body*' of an operative. These outcomes are similar to those encountered in the event of damage to underground gas mains, as the escape of high-pressure gas can also lead to fires and explosions.

In Ireland, the Electricity Supply Board (ESB) claims that the driving of earth rods (a synonym for pins) is the fifth commonest cause of making contact with live underground electricity cables (ESB, 2005), while Bord Gáis Networks in recent years have instigated a 'Dial Before You Dig' safety campaign in an attempt to avert unintentional service strikes.

Underground service strikes are not the only risk factor for surveyors who engage in this action, as there is also a possibility of being struck by the sledge while hammering the pins. This risk is greater than that of hammering stakes (as discussed in *Associated Hazard: 1H,* p.104), as in the majority of instances two people are required to drive in the pins (See Figure 2.8 below). Depending on ground conditions, an immense degree of exerted force may be required to ensure they are inserted firmly, thus the risk of missing the pin head and hitting the hands of the pin holder is considerable, especially as the target area is only 20 mm in diameter.

Additionally, there is the risk of a repetitive strain injury (RSI), as during any one day a surveyor may hammer hundreds of these pins.

Fig. 2.8 *A Surveyor Hammering Pins* © Kearns, 2012

In this case study, pins were used to facilitate the laying of blacktop (tarmacadam). This involved setting pins every ten metres on both sides of the proposed new road and taping them at the correct height so that a string-line could be pulled and dip levels taken. Pins of 1000 mm length were used. In an attempt to quantify the depth to which they were hammered, the pins were marked with an indelible marker (from bottom to top) at every 50 mm so as to allow the buried depth to be calculated. On average each pin was hammered 380 mm into the ground, thus creating a potential for service strikes.[85]

In relation to the risk of personal injury from hammering, the surveyors were observed missing the pin head with their hammer strikes on numerous occasions; however, no strikes to the hands or other body parts were recorded.

In relation to the potential for an RSI, two opposing pins were inserted every 10 metres, which resulted in the surveyor having to hammer 200 pins for every kilometre of potential roadway. However, one must consider that pins are needed for various strata of road development (road-base, base-course and wearing-course) and often got knocked due to the presence of heavy machinery. As a result, they must be set out again and re-hammered. It should also be noted that repetitive strain injuries develop from accumulative repetition of a biomechanical action. Therefore the hammering of pins may contribute to a harmful synergistic effect, as the same biomechanical motion is used to hammer LMA stakes, batter-rails and profile posts.[86]

[85] In order to ascertain this average, 100 pins from four different site locations were examined.

[86] Batter-rails is the name given to the construction of two parallel wooden posts and a crosscutting sloping board that facilitates the cutting of excavations or the formation of embankments. Profiles are horizontal boards on vertical posts that are positioned opposite each other in order to allow road base to be successfully aligned.

5.4.8 Associated Hazard 2H: Use of a digging bar

In instances of extremely robust underground material being encountered, a surveyor must often use a pointed digging bar to create a bore hole in order to allow a pin to be hammered into position (See Figure 2.9 below). Such digging bars are made of steel and hence are highly conductive should they pierce a live underground service. Newer models of digging bars with insulated handles are available; however, they were not in use on this project. As a consequence, the surveyors were exposed to the same risks of striking underground services as discussed in *Associated Hazard 2G: Hammering Pins* (p.117), albeit at an increased likelihood of occurrence due to the penetrating end of the digging bar being pointed.

Fig 2.9. *Using a Digging Bar to Set Surveying Pins* © Kearns, 2012

5.4.9 Associated Hazard 2I: Projecting rebar

Projecting steel rebar in the form of surveyors' steel pins presents an occupational hazard for the profession due to the risk of impalement. In this particular study, no accidents or incidents were observed as the hazard was contained by using protective mushroom caps. However, through the course of this investigation it was found that such caps were often removed and discarded by grading teams[87] or by high winds.

5.5 Levelling (Task 3)

Levelling is the process of determining the difference in elevation between two points and is an essential component of both the construction industry and a surveyor's work. On this particular project a dumpy level and measuring staff were used to perform this function. The dumpy level is a telescopic device containing a spirit level that is mounted on a tripod via a 360° rotatable base and tribrach. The measuring staff is an extendable graduated rod that is held vertically over the point of interest. By peering through the telescopic barrel, the surveyor can sight the measuring staff and, with the help of intersecting crosshairs, read off a measurement and compute a level.

Having conducted the STA, the following hazards were deemed to be associated with this task:

[87] A *grading team* is a colloquial expression used in the construction industry to refer to a group of individuals who pull string-lines from surveyors' pins and profiles in order to ensure ground conditions are graded to an optimum height for underlay or paving.

5.5.1 Associated Hazard 3A: Anatomical misalignment while using a dumpy level

While sighting a target through the eyepiece of a level, a surveyor frequently adapts a pose that is commonly known as a *dumpy level stoop* (See Figure 3.0 below). Such a physical stance is not a paragon of ergonomic excellence, as pressure is exerted on the individual's upper and lower back coupled with the rear of their lower limbs. During a productive day, hundreds of level sightings may be taken. This can result in the overtaxing of the aforementioned parts of an individual's musculoskeletal system.

In this study, *Surveyor A* reported experiencing no current or past pain while using the level; however, *Surveyor B* recounted instances of stiffness and ache as a result of using the instrument.

Fig. 3.0 *Dumpy Level Stoop* © Kearns, 2012

5.5.2 Associated Hazard 3B: Using a measuring staff

The measuring staff used by the surveyors on this project was of durable aluminium construction and extended from a height of 1.22 m to 5 m (See Figure 3.1 below). When fully extended the staff is very difficult to hold upright, especially in times of blustery weather. As a result, there is a potential risk of the staff falling from the operator's hands and causing damage to buildings, vehicles or pedestrians in the surrounding area.

Extending and retracting the staff also poses a challenge. This is primarily due to the sliding-lock mechanism that incorporates a shearing trap which can result in the operator's fingers being nipped.

Fig. 3.1 *A Fully Extended Surveying Measuring Staff* © Kearns, 2012

Diverse requirements on different contracts may also produce unique hazards. On this project, during one period of observation, the surveyors were asked to take inverse levels from a sewer line. This involved raising a manhole lid (successfully performed by a general operative) and dipping the telescopic surveying staff down into the hole in order to ascertain the level (See Figure 3.2 below). Such a task presents a significant biological hazard, as the measuring staff must be then removed and its telescopic function retracted by hand. During this particular instance, no personal protective equipment in the form of gloves was worn and neither were any antibacterial cleaning agents made available to use on the measuring staff.

Fig. 3.2 *Using a Measuring Staff to Dip a Manhole* © Kearns, 2012

5.5.3 Associated Hazard 3C: Surveying in excavations

During the observation period of this case study, the surveyors were observed entering excavations to take invert levels of pipes and determine the gradient and location of services. Such work can present the risks of soil engulfment, an inrush of water, the dislodgement of rocks and other material, atmospheric conditions unfit for human respiration, unsuitable means of access and egress, and the risk of being struck by items of site plant.

In Ireland, death in excavations primarily occurs from the collapse of side walls, strikes from mechanical excavator digging buckets, and machinery tipping over into trenches (HSA, 2007*c*).

In this case study, no instances were found of surveyors working in inadequately shored or battered excavations, thus the risk of sidewall collapse was removed.[88] However, on three occasions surveyors were observed working in close proximity to a mechanical excavator's digging bucket (See Figure 3.3 overleaf) and on two occasions working at locations where site machinery was operational too close to the edge of an excavation.[89]

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[88] Pursuant to Section 51(1) of the Safety, Health and Welfare at Work (Construction) Regulations 2006 there was an obligation on employers to ensure that all hazardous excavations in excess of 1.25 metres deep were shored (side walls supported) or battered (sidewalls sloped). Since the introduction of the Safety, Health and Welfare at Work (Construction) (Amendment) Regulations 2010, reference to the latter mentioned depth has been removed and such control measures must now be introduced at the site of all excavations where a fall or dislodgement of earth or other material which would strike, bury or trap a person is liable to occur.

[89] Regulatory guidelines (HSA, 2007*c*) dictate that machinery in operation on the banks of an excavation should be kept at a distance equal to the depth of the excavation from the edge.

Fig. 3.3 *A Surveyor Working in the Vicinity of Excavating Machinery* © Kearns, 2012

5.5.4 Associated Hazard 3D: Working at heights

At the onset of this case study it was envisaged that the surveyors would not be exposed to the hazards of working at height, as this research was conducted on a civil engineering project that did not contain the presence of existing structures or their forecasted construction. This proved untrue, as during the course of the research the surveyors were observed taking levels near the sides of unguarded excavations and in the vicinity of water culverts (See Figure 3.4 overleaf).

The risks associated with work at height are noteworthy. In Ireland, historically, the problem has been severe enough to occupy a significant proportion of the HSA's time and fiscal budget, with the rate of fall-related incidences reaching 180 per 100,000 construction workers in the year 2000.[90] More recent statistics,

[90] A 2007 report by Horwath Consulting Ireland and Bomel Consultants revealed that the HSA, between the years 1995 and 2006, spent approximately €39 million on a work-at-height safety campaign for the construction industry.

albeit improving, still reveal that the second most common cause of workplace death in the Republic of Ireland is falls from height, with 7 such fatalities recorded in the year 2016 (HSA, 2018c). European statistics show similarities, with the European Agency for Safety and Health at Work (EU-OSHA) stating that falls from height are the most common cause of death in the construction industry across all member states (EU-OSHA, 2013).[91]

Although the surveyors were fortunate that no incidents or accidents occurred during the observation period of this study, they did declare that they had never previously considered work at ground level (excavations and culverts) to put them at risk from falls from height, and that such a hazard had never been communicated to them before.

Fig. 3.4 *The Paradox of Surveying at Height While on the Ground* © Kearns, 2012

[91] For a more detailed understanding see Nadhim, E. A., Hon, C., Xia, B., Stewart, I., & Fang, D. (2016) *Falls from Height in the Construction Industry: A Critical Review of the Scientific Literature*. International Journal of Environmental Research and Public Health, 13(7), 638.

5.5.5 Associated Hazard 3E: Pulling string-lines

When assessing the hazards of geodetic engineering surveying, one must consider not only the hazards a surveyor is exposed to but also the hazards a surveyor has the potential to create. One example of this that became evident during the observation period of this case study was the pulling of string-line between two opposing pins. This is an action performed to enable an individual with a measuring tape to take a dip level in order to establish if road-base is of sufficient height (See Figure 3.5 below). Typically, this undertaking is performed by members of a grading team and not a surveyor. Nevertheless, during the course of this investigation it became apparent that this task was potentially hazardous for individuals who hold the string-line, as the operators of passing plant and machinery are unable to see the line due to the lack of contrast when set against the backdrop of road-base.

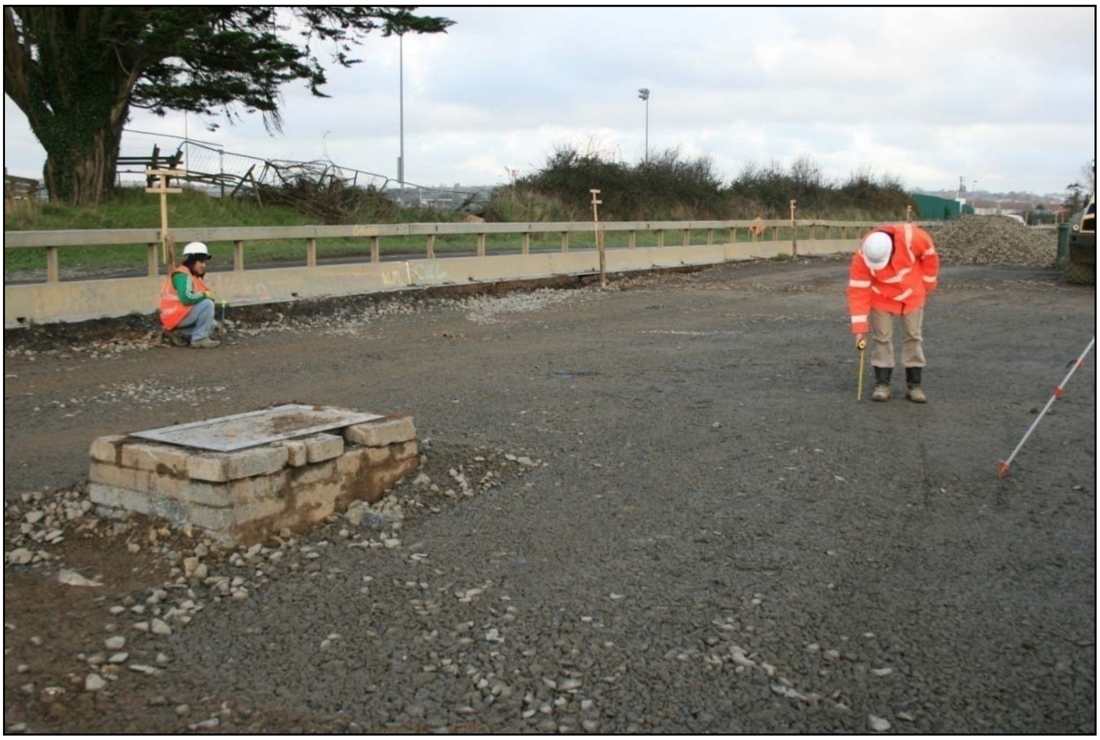

Fig. 3.5 *Dipping a String Line* © Kearns, 2012

As a consequence, such vehicles often drive straight through the line, causing it to be pulled from the operative's hands with immense force. This can result in injuries ranging from a minor cut to significantly more serious damage depending on what way the operative holds the string-line and whether or not they are wearing personal protective equipment in the form of gloves.

In this case study, during the second week of observation (day six), a general operative on site sustained a minor laceration to his hand in this manner.[92]

See Figure 3.6 below for an illustration of a surveyor simulating how a member of a grading team would normally hold a dipping string-line.

Fig. 3.6 *Pulling a Survey String Line* © Kearns, 2012

[92] Subsequent accident investigation by site management revealed that at the time of incident the injured party was not wearing gloves.

5.6 Discussion

Having conducted this case study, twenty-three hazards were identified and subsequently analysed. As a compendium they represent dangers from the physical, mechanical, ergonomic, chemical and psychosocial classes. However, despite addressing such a considerable aggregate, this study in no way conclusively illustrates the entire spectrum of dangers surveyors encounter. Those accustomed to the complexity of hazard assessment in a construction environment will realise that this is because no two construction projects are identical in form, manner, location, or system of work. Some sites have controls that eliminate the hazards in the first instance, while conversely other sites may create hazards that add to this list. Therefore a case study of this nature can only provide analyses from a small sample of the profession's work.

Aside from these constraints, the case study method of investigation also served as a barrier to providing a complete account of all the hazards that a surveyor encounters. This is because the individuals involved in this study repeatedly and resolutely claimed that there were other significant occupational hazards that they frequently encountered, such as working in confined spaces; crossing rail tracks, roads and rivers; the responsibilities and duty of care of young assistants (chainmen); and the construction of batter-rails and profiles. However, this type of work was not pursued during the period of observation and therefore could not be included in this report.

Nevertheless, despite these parameters the study did generate some noteworthy points of discussion from the hazards that were identified.

In relation to Task 1: *Establishing LMA*, the study revealed that the geodetic surveyors regularly carry equipment as heavy as that of their professional counterparts in the military. In light of this, it seems fair to form the conjecture that the average Irish surveyor is not, under the job specification, required to be of comparable fitness to military personnel, therefore such a degree of physical taxation can be regarded as a distinct occupational hazard.

Lone working was found to be a habitual occurrence for surveyors. Due to the range of possible dangers, difficulty was encountered in adequately determining levels of risk. This was compounded by a lack of design information that did not offer any guidance on how to safely establish LMA. This supports the earlier findings of Smith (1997), who reported that surveying information is often the last thing produced by designers and is rarely included in the preliminary drawings given to contractors. In view of this, a strong case can be made for the profession's education to incorporate a significant degree of health and safety tuition, as in many situations a surveyor must take sole responsibility for their own occupational wellbeing.

The profession of geodetic engineering surveying was also found not to be a sedentary occupation. In relation to the daily distance walked, an average of 6 km is probably well in excess of most professions'. Due to such a degree of movement, it is fair to assume that a surveyor will interact with many new environments. In this study, these new environments brought challenges in the form of weather conditions that were not conducive to maintaining positive health. Correlated to this was a lack of welfare and sanitation facilities that undoubtedly would not be tolerated in most occupational settings, but were endured by the surveyors due to the transient nature of construction work.

In relation to the equipment the surveyors used, GPS instrumentation was found to be relatively safe as it did not generate any of the major hazards that are customarily associated with construction equipment (noise, vibration, fumes, etc.); however, the more discrete hazards of lead poisoning, radio frequency exposure and battery security were discovered.

In relation to physical hazards, the study discovered that the clearing of vegetation to facilitate the hammering of posts was an arduous and sometimes dangerous task. Other projects can contain a significantly higher degree of clearing work than was attempted during the course of this investigation, therefore substantially increasing the prevalence of risk. Evidence of this can be found in the writings of Allen and Thallon (2011), who maintain that clearing work can be so extensive that a contractor should only obtain the services of a survey team that '*strive to minimise survey damage*' and '*save vegetation*'.

Following the clearing of vegetation, the subsequent hammering of stakes also created challenges, as there was a significant risk of self-injury from using the sledgehammer. Surveyors on this project were fortunate that the stakes they used came equipped with pointed tips, as wooden stakes for LMA can also be purchased with a flat head. The latter are less expensive and therefore sometimes used; however, when this occurs the task of hammering the stake into the ground becomes more laborious and as a consequence more dangerous.

Numerous chemical hazards were discussed as a result of using spray paint to mark the stakes. Apart from the hazards addressed in this report, the use of aerosol canisters also creates the risk of explosion should they be inappropriately discarded and driven over by items of site plant or machinery. It was also interesting to note that the paint manufacturer advocated the use of a *hand operated line marking trolley* to deploy the substance, yet ironically it is designed to be used manually.

In relation to Task 2: *Setting Out*, the study found a number of hazards. These hazards and their associated risks are notably dangerous when one considers the fact that evidence suggests (Muskett, 1995) setting out is usually the young, inexperienced engineer's first assignment in the industry.

The study found that at times the surveyors cut their own pins. This was an unanticipated finding that has serious safety implications due to their lack of formal training in the use of such equipment. However, this may have been an isolated occurrence on this site as a result of the host organisation's failure to fully anticipate the needs of the surveyors, and might not be a customary practice in the industry. Furthermore, site management failed to organise adequate means of transportation and carriage for the surveyors. This resulted in the surveyors being forced to move pins in a manner that resulted in a minor, yet dangerous, incident.

Findings demonstrated that establishing control points is hazardous to the ocular safety of the operatives. Should injury occur from this type of incident, repercussions can be exceptionally grave. The courts have reflected this view, and claims for eye injuries have been seen as low as €45,000 (*McGann v. M J Manning Construction*, 2003) and as high as €264,000 (*Williams v. Paddy Walsh Ltd.*, 2002).[93]

In relation to the total station instrument: as misuse can lead to erroneous measurements, the majority of safety documentation provided by the manufacturer described how best to keep the instrument safe. Such errors, although often detrimental to a project's success, have little or no impact on users' safety, health and welfare at work. Further investigation of the device and its use in a construction environment found that its operation was not without peril. Operators of the

[93] It should be noted that the latter award was made following the hammering of a steel nail that projected back into the injured party's eye.

instrument encountered its cumbersome nature, its intrinsically unsafe design, its battery-charging hazards and its potential to cause trips or slips. It is worth emphasising that surveyors who operate a total station are habitually required to use office computers to upload or download data to and from the instrument. Such work has associated ergonomic safety hazards that were not addressed in the body of this report. Furthermore, some total station instruments can introduce the operator to a risk of radiation exposure from internal components if their outer casing is opened or damaged.

The study suggested that surveyors regularly work near live traffic, thereby exposing them to the risk of being struck by moving vehicles. Such a finding is congruent with the earlier work of Holroyd (1999), who found that fast-moving traffic is a key concern for the profession. In relation to passing vehicles' speed, it was found that the vast majority of motorists paid little or no heed to the temporary recommended speed limits for passing the works location. It is also worth mentioning that passing vehicle speed seemed to be dictated in part by what the surveyors were doing: when they were using a total station instrument close to the edge of the road, as opposed to levelling or using a GPS unit, traffic seemed to slow to a very low speed. Although it cannot be explained why this occurred, anecdotally it may be argued that it was due to the visual similarity between the tripod-mounted instrument and a tripod-mounted speed camera. Further credence can be given to this conjecture when one takes into account the fact that the surveyors regularly took off their peaked safety helmets in order to get their eye nearer the viewing lens of the instrument, leaving them wearing just high-visibility yellow jackets.

The study found that surveyors work near plant and machinery. This is not a unique feature of this profession, as many construction trades work around plant and machinery. However, unlike other construction professions a surveyor rarely follows machines, as they instead must define the route for a machine to follow. As a result, they are being persistently pursued and pressurised to set out enough work to keep machines operating and a project progressing. Industry regulators have recognised the unassailable hazard that plant/machinery generates, and under the terms of the Safety, Health and Welfare at Work Construction Regulations S.I. No. 291 of 2013, auxiliary devices (beepers) and visual aids (CCTV cameras and mirrors) must be fitted to most machines. However, having analysed the fatality statistics highlighted in this report (p. 116), it is questionable whether the intervention has worked. Moreover, for each fatality there are multiple non-fatal injuries that tend to be of a severe nature given the size and power of the offending machinery.

During the course of this investigation it was determined that the hammering of pins was a hazardous activity. Reasons for this included the possibility of strikes to underground services, injury caused by the use of sledgehammers, and the onset of repetitive strain injuries. In relation to strikes to underground services, the pins in this study were hammered an average of 380 mm into the ground. Bord Gáis Networks advise that new mains be located at depths of 600 mm in footpaths, 750 mm in roads and 1100 mm in open fields. New services, however, are buried at depths of 600 mm rising to 375 mm. Due to the latter depth, strikes to underground services are possible for surveyors, especially when one considers the fact that Bord Gáis Networks extend the caveat that '*in some cases these depths are not achievable and note that older mains may have reduced cover*' (Bord Gáis Networks, 2011). The Electricity Supply Board (ESB) advises that underground electrical ducting is located at a depth of 450 mm in footpaths, 750 mm in farmland, forestry and carriageways, and 600 mm in certain carriageways and grassed areas (ESB, 2011).

However, they also say that the depth of cover on their underground services may be '*very shallow*' and that in certain instances no warning tape or protective measures may be in place (ESB, 2005). One should also note that the depths of both gas and electricity services are taken from finished ground level at the time of installation. Should future construction work or site clearance activity reduce these levels, dangerous underground services may well be within reach of surveyors' pins. Given the presence of this obvious hazard, it is legitimate to speculate that most well-managed construction sites would have a 'permit to dig' procedure in place. However, such preventive measures may not always work, as their success depends on accurate drawings, trial holes and CAT scans.[94]

In relation to the risk of injury from using a sledgehammer, the study emphasised that the danger is usually shared equally between two operators. On this project a 15 lb sledge was used; however, sledgehammers come in an assortment of weights and can often be found in excess of 30 lb. Accordingly, it is fair to deduce that the heavier a sledge is, the more potential it has to cause injury.

As regards the likelihood of developing a repetitive strain injury, the study reported that surveyors must hammer pins for the various strata of road development and that the same biomechanical motion is needed for the hammering of profiles and batter rails. For discussion purposes, it has been estimated that a surveyor must hammer 1200 such posts and pins[95] for every kilometre of newly constructed road (See Table 1.4 overleaf for a breakdown).

[94] A handheld cable avoidance tool (CAT) scanner will often be used in a construction environment to detect the presence of underground electrical services, as it has the potential to perceive current feed. However, some services such as underground public lighting supply have little or no current flowing through them during hours of daylight, thus rendering the CAT scanner an ineffective means of solely detecting the presence of underground electrical service.

[95] This calculation does not take into account the number of posts needed for establishing LMA.

Table 1.4 Quantities of surveying posts and pins needed for every 20 m of roadway

Type	**No. required**
Batter rails	4
Profiles	4
Pins (clause 804)	4
Pins (road-base)	4
Pins (base-course)	4
Pins (wearing-course)	4
Total:	24 or 1200 posts/pins per km (1000 m)

During certain instances of hammering pins the surveyors were found to use a digging bar if ground conditions were extremely robust. The hazardous possibilities of strikes to underground services again become noticeable. Moreover, at times, rocks and other impenetrable material are encountered and a surveyor may be required to cement around their pins in order to hold them in place. This action was performed by general operatives during the observation period of this case study and was therefore not discussed in the report. However, on other sites a surveyor may choose to concrete around their own pins, thus exposing them to certain hazards.[96]

In relation to Task 3: *Levelling*, hazards were also discussed. This was somewhat surprising, as levelling by its nature does not require the same degree of physicality as the other tasks depicted in this study. Yet despite this, ergonomic, biological and physical hazards all became apparent. The study also illustrated how

[96] Dry cement comes in bags that weigh 25 kg each. As a result, manual handing issues are of concern. When bags are opened, dry powder can be inhaled and cause irritation to the respiratory tract. If dry powder makes contact with skin or eyes, moisture levels in the areas can change the material into a more corrosive form, resulting in chemical burns and irritation. Following the mixing process, the dry powder changes form from a dust-like substance into a highly alkaline material that can have an extreme abrasive effect on human skin and cause caustic burns. Severity is determined by the duration of time wet cement spends on an individual's skin, with minor cases affecting the skin's epidermis and extreme cases causing third-degree burns.

the comportment of a surveyor can create dangers for other non-related parties. In this case, it was the pulling of string-lines and the hazard it created for grading teams that became evident. However, if all a surveyor's undertakings were analysed, many more hazards that affect others may become apparent.

5.7 Chapter Conclusion

Having conducted the case study, there is evidence that suggests a risk to the occupational health and safety of geodetic engineering surveyors, as multiple hazards were found to be associated with each of the three surveying tasks analysed.

No similar investigations exist in the body of published literature; therefore this case study may be of value and assistance to external organisations by allowing them to look at the represented hazards and evaluate if comparable dangers exist in their own organisations.

This investigation only examined the role of geodetic engineering surveying in a road construction project. Had the study for example focused on bridge or building construction, a very different array of hazards may have been highlighted. Similarly, the study was limited to just one observation period, and sufficient data for a meta-analysis could not be found.

In conclusion, given the number, frequency of occurrence, and potential negative outcomes of the hazards illustrated in this case study, a strong argument can be made for the profession's higher-level education to incorporate a significant amount of tuition in health and safety, thus reinforcing the arguments made in Chapter Four.

As a result, examining the extent of health and safety tuition that geodetic engineering surveyors receive during their higher-level education is a laudable pursuit, as it has the potential to discover current practices and conventions within this sector. In order to do this, a survey of higher-level institutes has been developed and administered, the methodology of which is discussed in the next chapter.

CHAPTER SIX

Research Methodology

6.1 Introduction

The following methodology has been written to systematically explain and justify the survey process. This will be achieved by describing the approach taken in a step-by-step manner that will enable replication of the study or permit validity analysis by a third party.

6.1.1 Overview of the Survey Process

An electronic database of all higher-level educational programmes that might contain taught elements in geodetic engineering surveying was created. Course directors and lecturers from the relevant programmes were then contacted and asked to confirm whether or not the selected programmes did contain such tuition. From this investigation, a sample frame was identified and an electronic mail [e-mail] questionnaire was developed. Following pilot studies, the questionnaire was distributed to 63% of the identified sample frame.

6.1.2 Pre-Survey Procedures

Prior to the study's commencement, an exploratory literature review using all available media was conducted to establish whether such research into the higher-level health and safety education of geodetic surveyors had been previously attempted. Despite an extensive investigation, no published evidence was found.

6.1.3 Survey Aim and Objectives

The aim of this survey was to quantify the amount of tuition students receive in occupational health and safety while attending higher-level educational programmes that contain taught elements in geodetic engineering surveying (GES). This aim was achieved by conducting a self-administered survey of all course directors or lecturers from universities and institutes of technology in the Republic of Ireland who oversee GES courses.

6.1.4 Survey Scope

Attempts were made to keep the parameters of investigation as broad as possible; however, some aspects of research were deemed to be outside the study's scope. Initially, it was proposed to conduct additional research into Post Leaving Certificate (PLC) courses, but this was not feasible due to the complexities of that system. Although numerous educational programmes in GES operate in Northern Ireland, this report does not attempt to address this demographic and is solely focused on the Republic of Ireland. The report's scope is also limited to addressing the opinions of course directors/lecturers and does not attempt to gain the views of any other parties.

6.1.5 Survey Format

The questionnaire of fifteen questions has been purposely designed to incorporate multiple formats of response.[97] Emphasis has been placed on creating questions that require a nominal dichotomous (yes/no) reply in order to simplify the process for the participant. Nine questions follow this format; the remaining six require responses that are derived from Likert scales, ordinal scales, and both multichotomous and categorical data fields. The survey also has one ratio-like question that requires a percentile response.

[97] The questionnaire can be found in Appendix 4, p. 296, however, the reader should note that the structure of the questionnaire is discussed in greater detail in the latter parts of this chapter.

6.1.6 Research Setting

Research was conducted from offices at the Department of Mechanical Engineering, National University of Ireland, Galway. Respondents could be visited at their place of work if they experienced difficulty in completing the questionnaires online, but this was not required. No work in a laboratory setting proved necessary.

6.1.7 Medium of Administration

SurveyMonkey™ is a web-based software survey package. It allows users to create, dispense and collate survey questionnaires of bespoke design. The package works by sending the participant an e-mail that contains a hyperlink to the questionnaire, which they in turn complete online and return in the same manner. It was chosen as the method of administration because of its relatively low cost,[98] its ability to allow an unlimited number of responses,[99] and the survey administrator's previous positive experience of using the software.

6.1.8 Required Resources

The survey process used telephone, computer and information technology programmes, and online search engines to establish the population sample frame. Similar resources were employed to distribute the questionnaire and analyse the returning data. As resources at the Department of Mechanical Engineering were used, minimum costs were incurred. When prospectuses were unavailable online, requests were made to administrative departments at institutes of education for the documents to be delivered by post. These requests were also facilitated at no fiscal cost to the survey administrator.

[98] €25.00 for a one-month package.
[99] 1000 responses as part of the €25.00 package; additional responses charged at €0.07 each.

6.1.9 Data Management and Security

Every effort has been taken to manage and protect respondents' data. The SurveyMonkey™ software uses Secure Sockets Layer (SSL) technology to protect users' information through a process of server authentication and data encryption. The programme's proprietors claim their system utilises the most advanced security technology commercially available; it includes firewalls, intrusion detection systems and other technology to prevent unauthorised data release.

Data storage and destruction have also been considered. Respondents' information was securely stored at offices of the Department of Biomedical and Mechanical Engineering in Galway and, after completion of the research and a significant retention period, will be destroyed.

6.1.10 Assumptions Made

A limited number of assumptions have been made. Firstly, the survey administrator has assumed that all participants in the study are sufficiently competent in the English language and are able to answer the questionnaire. Secondly, an honest response was expected from respondents, as the questionnaire does not attempt to implicate any party in a negative manner. However, there may be a degree of social desire to reply to the questionnaire in a way that portrays the respondent and their organisation in a more positive form than is actually the case. This degree of over-reporting may be a result of media attention on the high number of workplace accidents, and course directors or lecturers trying to appear to be proactively addressing the issue.

6.1.11 Ethical Consideration

Effort has been made to ensure the survey was administered and analysed in a fair and ethical manner. The purpose of the study was explained in writing to all potential respondents, and participation was voluntary—with agreement to complete the survey taken as an indication of informed consent.

In relation to personal data collection, anonymity could not be given to respondents, because in order to track levels of response, details of each participant were required. However, complete confidentiality was assured. Respondents also reserved the right to disconnect from the research at any stage.

6.1.12 Elimination of Biases

Attempts were made to eliminate any bias from the questionnaire. No leading questions or personal points of view on behalf of the survey administrator were detailed. Effort was also made to ensure no returning data was presented out of context. Consequently, the survey was administrated in a scientific and impartial manner. Nevertheless, it is worth noting that Gibbs (2007) argues that all research suffers from some degree of *reflexivity*: essentially the belief that research mirrors some of the '*background, milieu and predications*' of the researcher.

In relation to bias on behalf of the respondents, it was outside the scope of the study to identify its occurrence—although it was hoped that replies were objective and equitable.

6.1.13 Justification for a Qualitative Approach

The questionnaire adopts a qualitative approach in its design. Flick (2007) defines this as a method of '*analyzing experiences of individuals or groups . . . that allow the* *development of models and theories as ways of describing and explaining social or psychological issues*'. The advantages of such an approach are numerous, as a qualitative study has an ability to obtain diverse, in-depth information that captures people's perceptions and interpretations of their environment. Past research has also shown (Burns, 2000) that the converse approach of pursuing quantitative methods can denigrate humans' unique individuality and ability to decode life experiences.

However, the qualitative style is not flawless. Qualitative data can be subjective by nature, which in turn can result in concerns about validity and reliability. Detractors have also claimed the approach can be imaginative and speculative (Mishler, 1986; Riessman, 1993; Giorgi and Giorgi, 2003).

Nevertheless, for this investigation a qualitative approach was chosen as it was felt the method would lead to a greater comprehension of the sampled population's ethnography.

6.1.14 Justification for an E-mail Approach

Historically, the primary modes of survey administration have tended to be post, telephone and face-to-face interviews. In relatively recent times, administration of surveys by electronic mail has increased, for a number of possible reasons: Dillman (2007) found that web-based surveys provide capabilities far beyond those available for any other type of self-administered questionnaire. Weisberg (2005) documents how e-mail is one of the most unproblematic ways of getting surveys to computer-literate participants. Wright and Marsden (2010) go so far as to state that internet surveys encourage less use of any other techniques due to the versatility and applicability of the electronic approach.

E-mail has many other inherent advantages: it is less costly than other approaches; there are no geographic boundaries to administration; the duration of time needed to conduct an electronic survey is much shorter than postal methods;[100] it is more secure and offers more control over who answers, as it is sent to a private account which is typically password encrypted; while from a labour perspective, an e-mail response prevents transcription problems that occur in telephone and face-to-face interviews.

The technique, however, is not infallible. Bourque and Fielder (2003) report that a response rate as low as 10–20% is common in online surveys. Another major disadvantage to the e-mail approach is that, unlike the telephone method, contact information directories do not exist. This can result in significant time being spent establishing addresses.

Having evaluated both the advantages and disadvantages, it was decided that e-mail would be the most suitable method of survey administration. Support for this decision was also found in available published literature, as Carley (1996), in early studies of faculty use of computer-related technologies, established that close to 90% had e-mail access. More recent research by Weisberg (2005) illustrated that third-level faculty members are very accustomed to using computers, and if presented with a choice, many would favour completing a survey through this medium than any other. Dillman (2007) concurred with these findings by stating that certain populations, such as college faculty members, generally have internet access and for this faction e-mail surveys have only minor coverage problems.

From a historical perspective, the literature also points to a sufficient level of response from using an e-mail approach in an academic setting. Kiesler and Sproull

[100] Czaja and Blair (1996) found that the length of time to conduct a mail survey is fairly consistent—usually 8–10 weeks regardless of the sample size and its geographic distribution.

(1986) published findings of the first university-derived e-mail survey in *Public Opinion Quarterly* as early as the 1980s; their research examined survey response rates using e-mail and postal mail in a computer-intensive environment (Carnegie Mellon University, USA). Results revealed that although e-mail technology was novel and not widely used by the general public, response rates from the academic cohort were comparable with a postal distribution (75% returned the paper survey; 67% returned the e-mail survey).

6.2 Procedures Taken in Determining Population

6.2.1 Target Population Criteria

The target population for this research was course directors or lecturers of higher-level programmes that offer tuition in geodetic engineering surveying. As a result, stratification of variables such as age, sex and other demographic information was deemed unnecessary for this study. Although not specifically stipulated as respondent criteria, a limited number of assumptions have been made about the participants, as illustrated in sections 6.1.10 (p. 144) and 6.2.2 below.

6.2.2 Competence of Respondents

Complete competence of each respondent to answer the questionnaire was assumed. This comes from the fact that every respondent is an academic director or lecturer and is being asked for information concerning a programme they oversee. Similarly, the respondents' occupation led to the assumption that neither language nor literacy issues would be of concern.

6.2.3 Scoping Population Database

As no existing population database could be found, higher-level college prospectuses (online) were examined from all seven universities and fourteen institutes of technology based in the Republic of Ireland. Any course that contained tuition in GES had details of its particulars extracted and entered into the database, along with contact details of the course directors or lecturers who oversaw such programmes. In order to ensure the database was representative, courses where it was felt there may be even a small chance of tuition in geodetic surveying techniques were also selected. In total, 165 courses were entered into the database.

No specialised training was required to develop this database; however, some knowledge of the higher-level education systems in the Republic of Ireland was beneficial. The process presented complexities due to difficulties in finding the population and the sheer myriad of courses offered at tertiary level.

6.2.4 Sample Frame Development

Sapsford (1999) defines a sample frame as a 'complete list of the population'. However, the population that Sapsford refers to is an exact catalogue and not the results of exploratory research like that seen in section 6.2.3: *Scoping Population Database*. In this instance, the database served as a calculated estimate of who the population might be and was compiled on the judgement of the survey administrator. In order to verify its accuracy, each of the 165 course directors and lecturers listed on the database was contacted via e-mail (see Appendix 1, p. 293) to confirm whether or not their programme contained taught elements in geodetic engineering surveying. Consequently, the population database was compressed to an accurate list of 71 courses. This list henceforth became the sample frame.

In relation to degree of difficulty, screening the scoping population database to form the sample frame was less complex than creating the original database. This was mainly due to the relative ease with which course directors and lecturers could be contacted, as their details could be extracted from the scoping population database. The overall aim of the process was to develop a quality sample frame with no under- or over-coverage,[101] of either a random or systematic nature.

6.2.5 Quality Control

Gibbs (2007) found that many ideas about research quality have been developed in the context of quantitative studies. This is mainly due to complexities in ascertaining the value of subjective qualitative data. In the present study, such difficulties were compounded by the fact that neither the sample frame nor the questionnaire had ever been previously trialled. To combat this, repeated quality spot-checking was incorporated into all aspects of the survey process by the survey administrator and an independent appointee.[102]

6.2.6 Sample Size

Sapsford (1999) defines a census as 'collecting data on every single case within a population'. At the study's conception it was originally intended to distribute the survey to 100% of the sample frame, thus forming a census. This plan ended due to the problem of sample multiplicity—essentially, members of the sample frame appearing more than once on the list. As many of the higher-level programme directors and lecturers oversee multiple courses, this became a significant problem,

[101] Terms used to denote the phenomenon of either not including all population units into the sample frame or including too many.
[102] PhD student based at the Department of Mechanical Engineering, NUI, Galway.

with thirteen individuals (overseeing 34 programmes) appearing on the list more than once.

The issue of multiplicity could have been ignored and the questionnaire distributed as normal, but it was considered unreasonable to ask participants to complete more than one survey. In addition, by accepting feedback from the same respondent twice, the validity of the entire survey could be threatened. The findings of Czaja and Blair (1996) affirmed this: their research established that by ignoring the problem of multiplicity, bias can be introduced into the survey process. To address this concern, Czaja and Blair advocate ‘purging’ the sample frame of such duplication. However, in the context of this study, such action would make it impossible to conduct a census-style survey. There would also be validity issues in deciding which courses to purge from the list; for example, if Course A and Course B have the same director, a survey administrator must decide which one should be removed, a choice that could introduce preferential bias.

In the end, it was decided to remove all instances of repetition from the sample frame, as the issue of multiplicity could not be ignored. In order to equitably determine which courses should be reintroduced to the frame, a sub-list of all duplicated names and corresponding courses was made. From this list, each instance of duplication was arranged into groups and assigned a cluster number (1–13), an example of which can be seen in Table 1.5 overleaf. The aim of this division was to allow the selection of one course from each cluster for inclusion in the sample frame.

Table 1.5 Example of stratified cluster, using fictitious names in order to protect confidentiality

Name	Course	Institution	Cluster No.
Dr John Smith	B.Sc. Land Surveying Level 8	University A	1
Dr John Smith	H.Dip. Land Surveying Level 9	University A	1
Dr John Smith	Cert. Land Surveying Level 6	University A	1

As previously mentioned, the selection of one course from each cluster presents an opportunity for the introduction of preferential bias. To overcome this, numerous approaches were considered. The most risk-free option would have been to simply exclude individuals for whom multiplicity presented a problem; however, this option would see the sample frame diminish to an unacceptable size. Alternatively, and in cases of such multiplicity, the questionnaire could have been distributed to other academic staff members, but this would see a distilled target population sampled and lead to correlation analysis problems.

Another commonly used technique for selecting the participant from each cluster is the *Next Birthday Method*, whereby the director or lecturer whose birthday is next would be chosen. However, this method would only work in clusters containing multiple names—not just one. Similarly, the widely used Kish algorithm for random selection[103] and the use of Random Digit Dialling (RDD)[104] were both deemed unsuitable.

Following consultation with faculty members and the project's research supervisor, it was ultimately decided to go with a simple names-out-of-a-hat selection for each cluster. This method is not perfect, as there is no guarantee that the courses selected would be representative of the three HETAC levels being examined, but it was considered to be the best available approach given the scope of the study.

[103] For a more detailed overview of this method see Bickman and Rog (1998) *Handbook of Applied Social Research Methods,* pp. 446–447.
[104] Ibid. pp. 440–443.

Such compromise accords with the writing of Czaja and Blair (1996), who found that some degree of inaccuracy is present in all sample frames.

Having carried out the selections from each cluster, the sample frame was reduced in size from seventy-one to forty-five.[105] This rendered a census-style survey impossible, but as forty-five represents 63% of the entire sample frame, a pseudo-census was conducted.[106] Albeit not as comprehensive as a full census, this form of sampling allows results from the aggregate to be generalised and inference made about the entire population.

6.2.7 Collection Method

A four-step process was used to maximise the response rate. To begin, the questionnaire was e-mailed to participants (see Appendix 2, p. 294) accompanied by the covering letter (the content of which is discussed in the latter sections of this chapter). Following a period of non-response, a reminder e-mail was sent with a replacement questionnaire (see Appendix 3, p. 295). If a response was still not forthcoming, another e-mail could be sent to the course director or lecturer directly, asking them to partake in the study and confirming that there was not some factor affecting the ability to respond (holidays, sick leave, inability to understand the questionnaire, etc.). If all previous attempts failed, the final approach of a direct telephone call was made if required.

6.2.8 Survey Collection Time Period

In keeping with Bourque and Fielder's (2003) suggestions, ten days after the first mailing was sent out, the second e-mail accompanied by the replacement

[105] The figure of forty-five represents the final number, having deducted five individuals that assisted in the pilot study, details of which are provided on page 161.
[106] A *pseudo-census* is the term given to sampling nearly the entire population.

questionnaire was delivered. The penultimate approach, if necessary, was then made after five more days, with the final telephone contact taking place after an additional five days (20 days after first contact).

6.3 Questionnaire Development Procedures

6.3.1 Questionnaire Development

Bourque and Fielder (2003), on the topic of questionnaire development, advocate either adopting or adapting previously used questionnaires. Such an approach can reduce time spent developing, justifying and validating a questionnaire, while also allowing meta-analytic comparison of results. However, in relation to this research, no suitable previously used questionnaire battery could be found despite a detailed literature review. This resulted in the need to develop a bespoke questionnaire.

6.3.2 The Selection of a Self-Administered Survey Instrument

For this study, a self-administered survey instrument was devised. This decision was taken having evaluated other approaches and carried out an assessment of the advantages and disadvantages. Bourque and Fielder (2003) argue that self-administered questionnaires are one of the most frequently used methods of collecting data and cost 50% less than telephone and 75% less than in-person interviews. Aside from the fiscal benefits, in this case self-administered questionnaires allowed for wider geographic coverage, larger sampling, and less administrative personnel. In addition, there is a strong argument that information elicited from self-administered questionnaires is one of the strongest forms of feedback—mainly due to the respondent having more time to think and respond at a time that suits them. The combination and assessment of all of the above factors led to the selection of self-administered questionnaires for this research study.

6.3.3 Questionnaire Design

Attempts were made to ensure the entire process fit the respondents, as opposed to forcing them to adapt to the process. This was done to facilitate participants' satisfaction and in turn heighten levels of response. As a result, the questionnaire was presented in a standardised manner with questions following a numerical sequence and text reading left to right. Given the estimated age of respondents (≤ 65), it was deemed unnecessary to use a larger typographical font size. Twelve Times New Roman was selected using double spacing on a neutral background.

In addition, careful consideration was given to the answering process. Studies by Israel (2005) found that a larger sized reply box for questions can lead to more detailed answers; however, this was in relation to mailed surveys. Smith et al. (2006) argue that web survey answer size boxes, once schematically similar, have less importance because respondents can write as much as they want. In accordance with the recommendations of Smith et al., the reply boxes used in this survey were of similar size, proximity, and symmetrical design. This is in keeping with the Gestalt principle known as the *Law of Pragnanz*, where it is hoped that abiding by similarity and spatial homogeny can reduce levels of respondent perplexity. Additional measures for providing the most suitable questionnaire included the following:

- The word *questionnaire* was used as opposed to *survey*. This was an attempt to reduce any possible confusion for the respondent due to the primary focus of the research being on surveying.

- Questions were phrased in a non-cognitively-burdensome manner with uncomplicated prose.
- The questionnaire's length was restricted to fifteen questions so as not to over-tax the respondent.
- Dillman (2007) advises against asking respondents to make unnecessary calculations in a survey. Although this questionnaire does seek a percentile response in one question, it did not require exact calculation—only an approximate value was sought.
- Linear vertical answer sequences were used, due to research by Tourangeau, Couper and Conrad (2004) demonstrating that participants apply certain visual heuristics: expecting 'up' to be 'good' and more positive categories in a list to appear at the top.
- Given the obvious educational attainment of the respondents, examples of how to tick boxes was deemed unnecessary and unprofessional.

6.3.4 Aims of Particular Survey Questions

The survey administrator was aware that participants' time was limited. Consequently, attempts were made to ask only the most pertinent questions. In order to do this, the aim of each question[107] was carefully considered:

Question 1 and ***Question 2***: The opening questions attempt to establish the approximate numbers graduating from the relevant programmes and the ratio of males to females. By determining these figures, an overview is ascertained of the numbers and demographics of those entering the workforce with or without education in the discipline of occupational health and safety.

[107] A copy of the questionnaire can be found in Appendix 4, p. 296.

Question 3: This can be categorised as a qualifier question; by asking the participant to categorically state whether or not their educational programme contains a taught element in occupational health and safety, the survey administrator splits the respondents. Those that answer *NO* do not qualify to answer *Questions 4*, *5*, or *6* and instead must skip to *Question 7*. Those that answer *YES* proceed in numerical sequence. The aim of integrating this skip-pattern is to keep the questionnaire relevant for all participants.

Directors and lecturers who oversee programmes that do contain elements of occupational health and safety are asked, through the provision of *Questions 4–6*, to quantify the level of tuition. This is done by stating whether the classes are components of modules or standalone modules; elective or mandatory; of specific relevance to geodetic engineering surveyors; and contain a high or low weighting assigned to the topic (hours spent/ECTS credit value). Elucidating this information enables the survey administrator to obtain a synopsis of the average emphasis higher institutes of education place on the provision of occupational health and safety training in their core syllabus.

Question 7: This question initiates the second section of the survey and deals exclusively with geodetic engineering surveying. Participants are asked to declare whether students undertake work experience with surveyors, thus attempting to highlight whether or not students are being sent to the workplace at a formative stage of their education—either with or without health and safety training (as confirmed by previous sections in the questionnaire). The question is significant due to the correlation between youth and workplace accidents.[108]

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[108] The International Labour Organization in 2018 produced a report that cites studies claiming the incidence of non-fatal injury at work was more than 40 per cent higher among young workers between the ages of 18 and 24 than among older workers – See ILO (2018) *Improving the Safety and Health of Young Workers.* Geneva, Switzerland for more information.

Question 8: This question attempts to gauge participants' familiarity with health and safety advisory services in the event of students seeking specific information on geodetic engineering surveying. Four options are given (Health and Safety Authority, Health and Safety Executive (UK), Royal Institute of Chartered Surveyors, Irish Society of Surveyors) and the respondent is asked to pick one or all from the list. There is also an option to select *Other*, and specify what is meant by that selection. In the event of the respondent selecting one of the aforesaid four organisations, it can be argued that directors and lecturers are not entirely familiar with the health and safety services in this area, as none of the organisations listed have publications on occupational health and safety specifically for geodetic engineering surveyors.

Question 9 and ***Question 10***: These questions are aimed at determining whether or not course directors and lecturers would see benefit in a Safe System of Work Plan (SSWP) for geodetic engineering surveyors.

Question 11 and ***Question 12***: These questions have a similar aim to those discussed in the previous paragraph; however, instead of investigating the need for SSWPs, the development of a Code of Practice and a Skills Card is discussed. Correspondingly, these questions have the potential to provide some rationale for a subsequent development of a Code of Practice and a Skills Card, albeit outside the scope of this study.

Question 13 and ***Question 14***: These questions attempt to gauge course directors and lecturers' knowledge of the relationship between construction regulation and the GES profession. If respondents are unaware of deficiencies in the legislation, it can be argued that students may be wrongly taught that the Safety Health and Welfare at

Work (Construction) Regulations encompass provisions to protect surveyors, thus misinforming students on levels of regulatory protection.

Question 15: The final question aims to quantify the amount of consideration course directors and lecturers generally give to occupational health and safety. By asking this question, an approximate estimation can be formed as to whether or not those responsible for students' education perceive health and safety to be a pertinent subject.

In line with best practice, the questionnaire ends by asking respondents if they wish to receive a copy of the overall results. This offer is based on attempts to create a degree of benefit in the questionnaire for the participant. There is also a section that gives participants the opportunity to add any comments they may have.

6.3.5 Coding

Gibbs (2007) refers to coding as a way of indexing or categorising text in order to establish a framework of thematic ideas. Essentially, it allows for detection of patterns within set variables. In relation to questionnaires, pre-established answer variables can be assigned a surreptitious code. Upon return of a questionnaire this facilitates analysis, as data can be easily themed. However, Auerbach and Silverstein (2003) found that coding for qualitative studies is based on the premise that an analyst will undoubtedly experience difficulty with prolix transcripts. As this study follows a format that does not utilise such transcription, the application of coding was not employed.

6.3.6 Questionnaire Delivery

Given the occupational profession of the respondents, care was taken not to deliver the questionnaire during typical student exam times or standard vacation periods. It was also postulated that the day of the week on which the survey was sent ought to affect response rates. It was speculated that Monday could be a catch-up day for many, following the weekend break, while Friday could typically be a day where respondents would be under pressure to complete work. Consequently, both days were eliminated. This left Tuesday, Wednesday or Thursday to deliver the questionnaire. Again, an assumption was made that many would opt to complete the questionnaire 'later' or 'tomorrow'. Therefore, Tuesday was chosen as the distribution day for the survey. As this approach was based on conjecture, it was expected that no evidence would be found on whether the approach had or had not increased rates of response.

6.4 Procedures Prior to Questionnaire Deployment

6.4.1 Pre-Test of the Questionnaire

Prior to the wide scale distribution of the questionnaire, a pre-test was circulated to members of faculty and PhD students at the Department of Mechanical Engineering, National University of Ireland, Galway. The aim of this procedure was to use departmental resources in identifying possible defects in the questionnaire. The review team were given an identical questionnaire to the one members of the sampled population would receive. They were asked to work through the survey on a question-by-question basis and give feedback on any suggested changes. In total, four members of the department were used. The pre-test highlighted a number of minor issues which led to certain revisions being implemented at the discretion of the survey administrator.

6.4.2 Covering Letter

In order to seek participation in the study, an explanatory covering letter (see Appendix 2, p. 294) accompanied the questionnaire. This aim of this letter was to convey the importance of the survey and encourage individuals to partake in the research. The college logo was attached to the head of the letter. Dillman (2007) found that such an approach may help encourage a survey response, because it shows sponsorship by a legitimate authority. Dillman also found that personalisation is important for achieving response, thus concurring with Bourque and Fielder (2003) who state that the initial contact should be a personalised greeting so as to increase the sense of ownership. As a result, the letter was personally addressed to each potential participant.

The brevity of readers' attention was not underestimated. Consequently, the opening paragraphs stated who the survey administrator was, what they wanted, and the primary aim of the correspondence. Following on from this, the study's format, confidentiality statements and instructions for completion were given. In closing, the letter gave contact details for clarification of any matter and thanked the recipient for their forecasted participation in the study.

6.4.3 Pilot Study

A *pilot study* is a feasibility trial run in preparation for a main study. Aimed at improving the validity of research, pilot studies can test the adequacy and workability of a questionnaire by uncovering potential problems. However, it must also be noted that these studies have some disadvantages. In the event of a survey administrator adapting all suggested changes without circumspectly evaluating each one, contamination of the main study is possible. This can often be due to social desirability bias on behalf of those piloted, as they know their help is being sought and they feel compelled to distribute advice, regardless of its validity. Another distinct disadvantage is that data from pilot studies cannot be included in the reported findings from the main study.

In relation to this survey, a pilot study was used after evaluation of both the advantages and disadvantages. Five individuals were randomly selected from the sample frame and sent the questionnaire in the same format as it was intended to appear in the main study. The only difference was that on completion of the questionnaire, those piloted were asked to give feedback on any problem or ambiguities they encountered. The highlighted issues were then addressed at the discretion of the survey administrator.

6.5 Procedures Upon Return of Questionnaires

6.5.1 Required Rate of Response

As no similar studies were identified, a benchmark level of response was unavailable. Therefore, this study adapted the classic Cochran (1977)[109] formula for calculating a representative sample:

$$n = [1 - \frac{n}{N}] * \frac{t^2\,(p * q)}{d^2} = \mathit{finite\ population\ correction} * \frac{\mathit{probability\ level} * \mathit{variance}}{\mathit{confidence\ interval}}$$

Upon selection of a 95% confidence level and mathematical calculation, the minimum required rate of response needed was twenty-nine (64% rate of response).

[109] William G. Cochran, Professor of Statistics (Emeritus), Harvard University; author of *Sampling Techniques* (1977).

6.5.2 Achieved Rate of Response

The survey yielded a 69% rate of response (83% from universities and 93% from the institutes of technology), details of which are provided in Chapters Seven and Eight.

6.5.3 Presentation of Data

Attempts were made to present all findings in a transparent and lucid manner. As most of the respondents' feedback was derived from nominal dichotomous questioning, a combination of pie charts and bar charts was chosen to display the findings. This decision was taken following an assessment of available presentation techniques for suitability and visual effectiveness.

6.5.4 Statistical Analysis Performed

All returning data was subjected to statistical analysis. Through the use of descriptive statistics, graphical representations were formed. Measures of central tendency were used to calculate the mean, median and mode of certain responses. Statistical outliers were treated as anomalies, and patterns of both response and non-response were checked to ensure they were proportionate.

6.5.5 Validity

Fink (2003), when discussing questionnaires, defines validity to be the '*degree to which a survey instrument actually measures what it purports to measure*'. In relation to this survey, validity was considered on multiple levels: the questionnaire has a clearly defined scope, questions are suitably correlated to the study's aim, and the study assesses the intended variables. As a result, content validity has been preserved.

The study also availed of multi-person reviews through the use of pre-tests and pilot studies (as detailed in sections 6.4.1 and 6.4.3, pp. 160-161). This led to minor revisions and in turn face validity—as on the surface, the questionnaire seemed to ask the most pertinent questions and its prose was pitched at a suitable level.

On the subject of criteria, predictive validity tests were not applied, and as no comparison data was available, concurrent validity testing was also not used. However, construct validity can be predicted, as the survey set out to gain feedback from academic staff and this is precisely what was achieved.

The possibility of respondents having the ability to reduce validity has also been considered. This threat stems from the prospect of participants speculating on the intent of the study and, consciously or subconsciously, altering their response to convey an answer they 'think' is correct. However, similar to aspects of *social desirability* discussed in section 6.4.3 (p. 161), this is based on conjecture, with little available means of detecting or preventing its occurrence.

6.5.6 Reliability

A reliable survey process is one that is dependable and free from error. In relation to this study, intrarater reliability was preserved by randomly checking raw data and statistical summations. However, as the study was conducted by a single survey administrator, interrater reliability could not be tested. Similarly, as the questionnaire could not be administered longitudinally on the same participants, the use of test-retest reliability was not possible, and Cronbach Alpha tests were considered outside the scope of research. Consequently, reliability testing was limited to the aforementioned process of random checking. Writing on reliability, Alwin (2007) observed that maintaining reliability depends on repeated measurement; as a result, these random tests were performed systematically. Although not ideal, random checking was sufficient for this study, as survey reliability by its nature subsumes the other psychometric considerations of validity (as discussed in section 6.5.5, p. 163) and process error management as detailed in the following section.

6.5.7 Process Error

In keeping with the recommendations of Lo (2009), the possibility of error was considered at all stages of the survey process. Consequently, the sample frame was checked for the presence of sampling error[110] and coverage error.[111] Similarly, error-detecting pre-tests and pilot tests were conducted prior to the survey's launch, as detailed in sections 6.4.1 and 6.4.3 (pp. 160-161). Attempts at error identification were also made. This was done by subjecting the returned questionnaires to analysis in an effort to identify any trends of difficulty that the respondent might have experienced.

In relation to measurement error, all statistical summations were checked for erroneous data, firstly by the survey administrator, and then by an independent party.[112]

Despite such precaution, some random error may exist in this study, as Burns (2000) found that random error is difficult to avoid even with the best sampling techniques. Nevertheless, from a survey administrator's perspective, every effort was made to eliminate its occurrence. Error on behalf of the respondents was also considered. Such error is known as *response effects* and has been defined by Sudman and Bradburn (1982) to be the '*amount of error in the answers to questions that are*

[110] In essence, the selected sample not being representative of the population.
[111] Either too much or too little emphasis placed on one demographic.
[112] Ph.D. student based at the Department of Mechanical and Biomedical Engineering, NUI, Galway.

due to factors such as faulty memory, *[and] the respondent misunderstanding the question*'. However, due to the idiosyncratic nature of this error type, no action could be taken to identify or prevent its occurrence.

Having implemented the aforementioned methods, the next chapter outlines the derived results.

CHAPTER SEVEN

Results

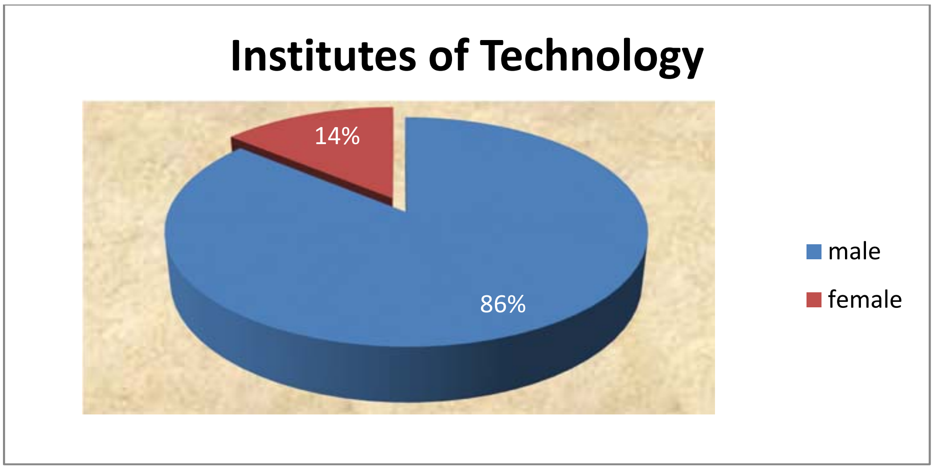
Fig 3.7 Average number of graduates per year from each Irish GES programme

39 per year from each institute of technology

34 per year from each university

Total number graduating per year: **1498**

Fig 3.8 Approximate ratio of graduating males to females on Irish GES programmes



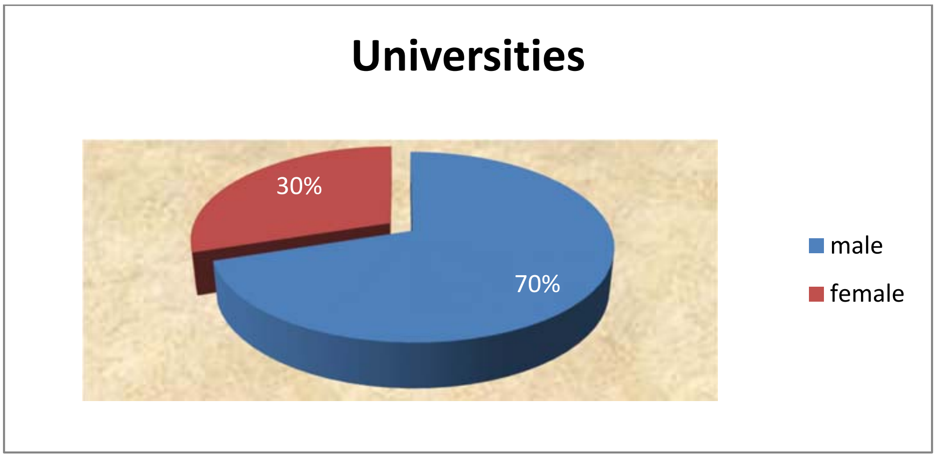
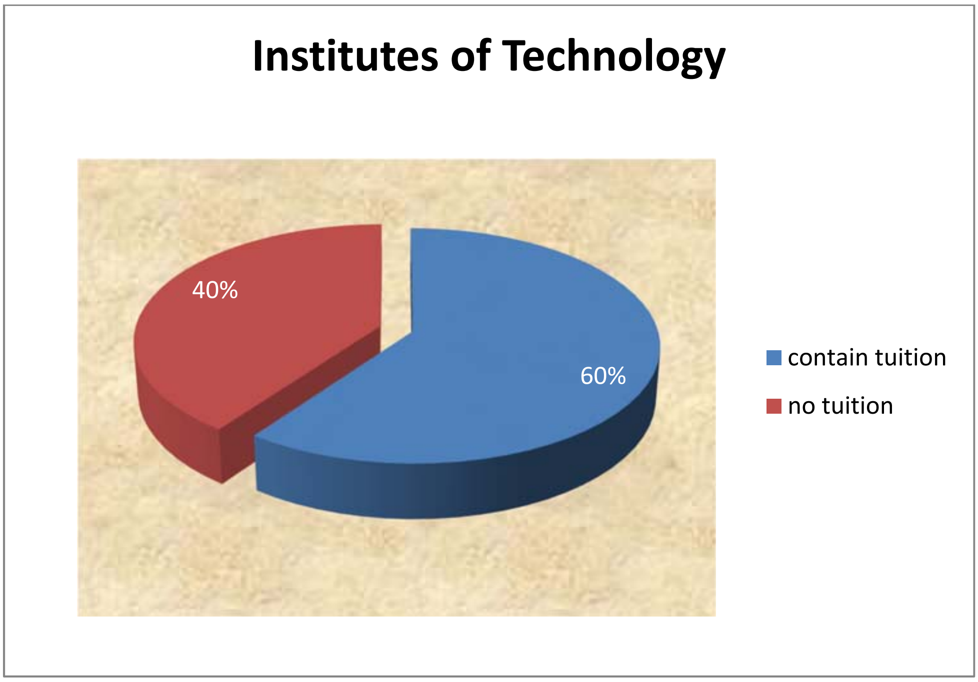


Fig 3.9 Ratio of Irish GES programmes that contain tuition in occupational health and safety



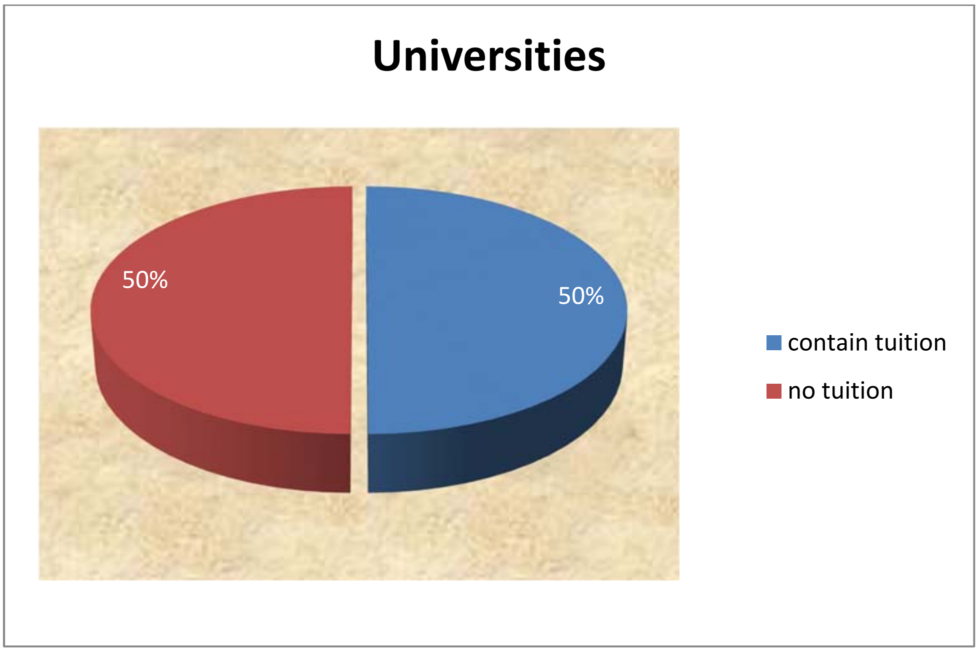
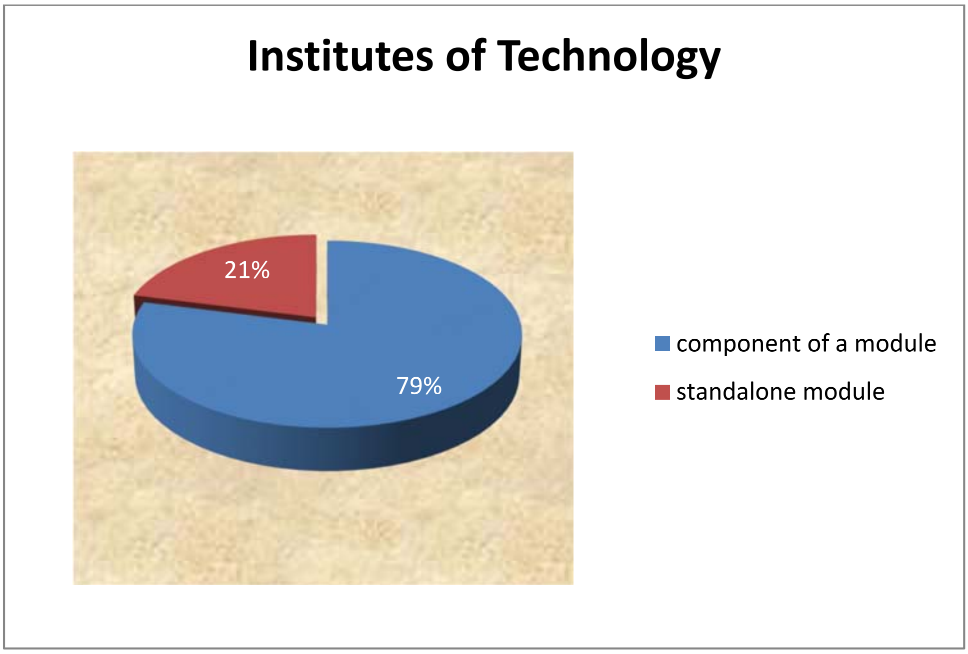


Fig 4.0 Configuration of occupational health and safety modules offered on Irish GES programmes



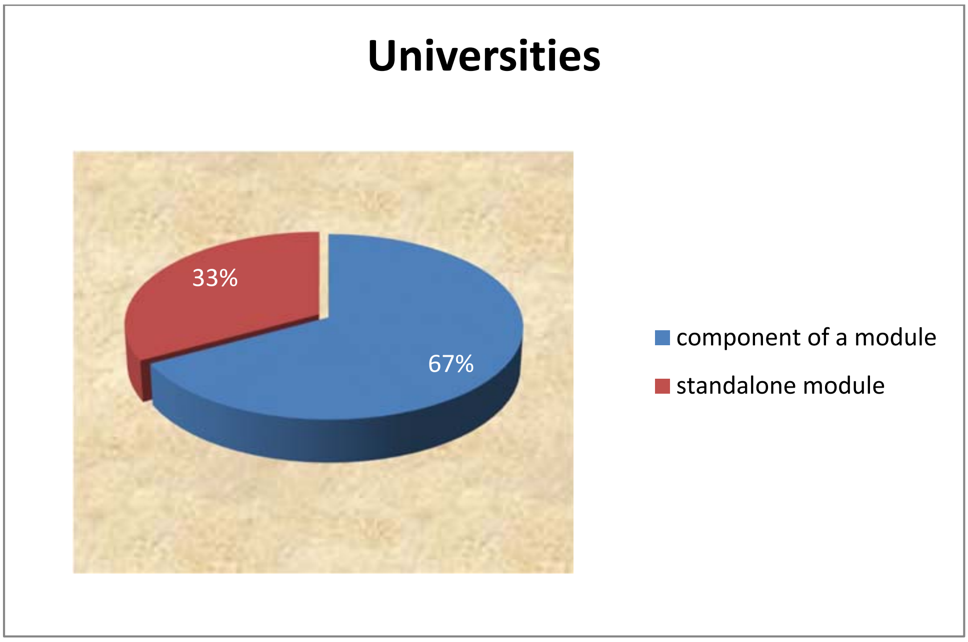
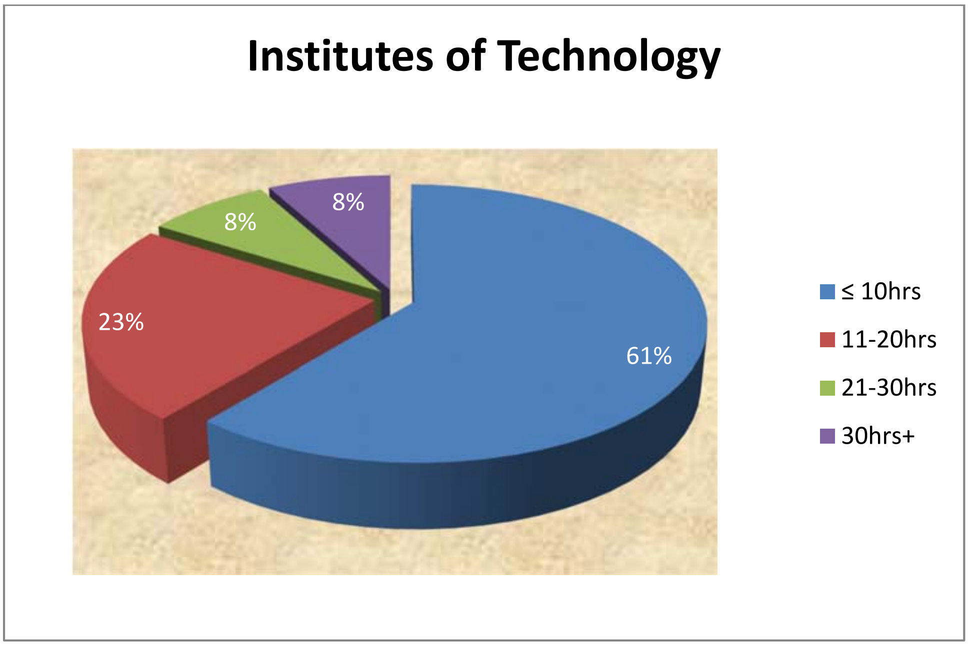


Fig 4.1 Duration of time spent teaching occupational health and safety when it is offered as a component of a module on Irish GES programmes



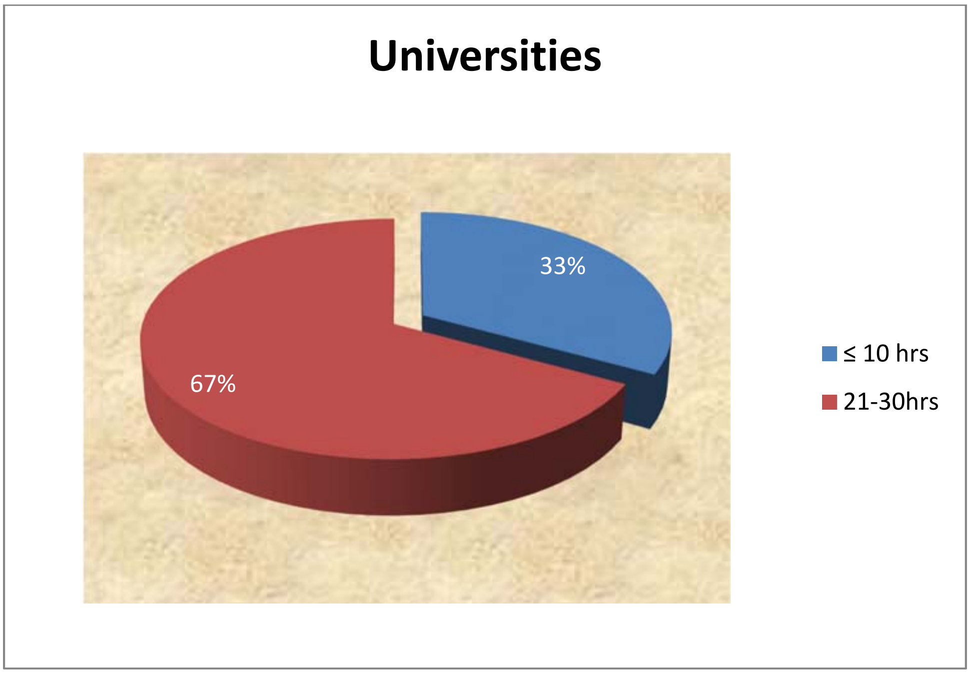
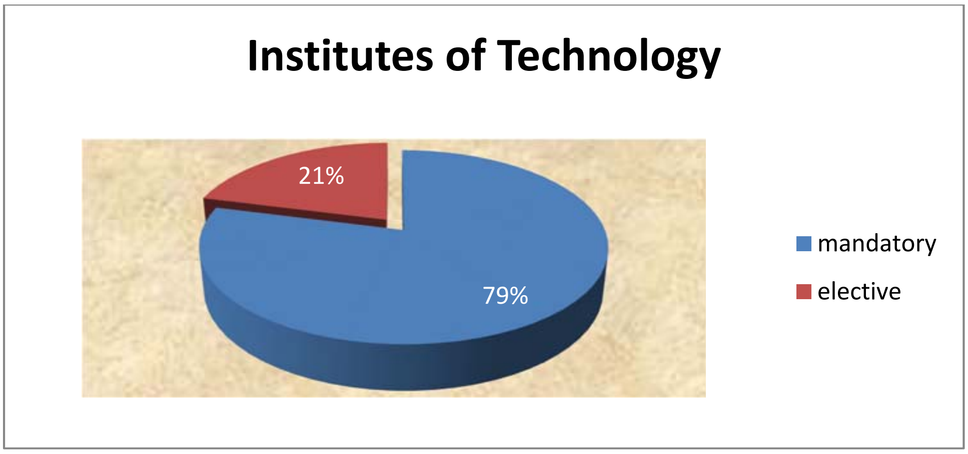


Fig 4.2 Average number of ECTS credits awarded for modules in occupational health and safety on Irish GES programmes

5 ECTS awarded by the institutes of technology

5 ECTS awarded by the universities

Fig 4.3 Classification of occupational health and safety classes offered to students on Irish GES programmes



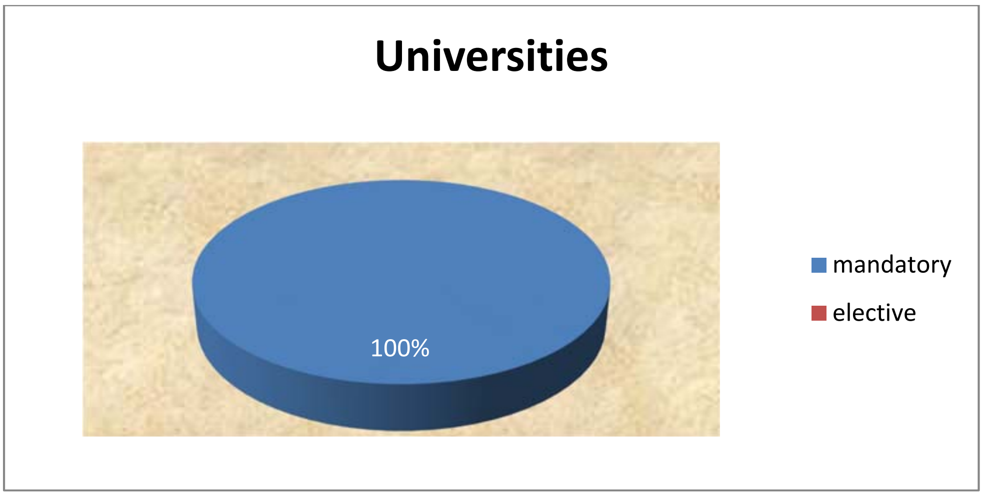
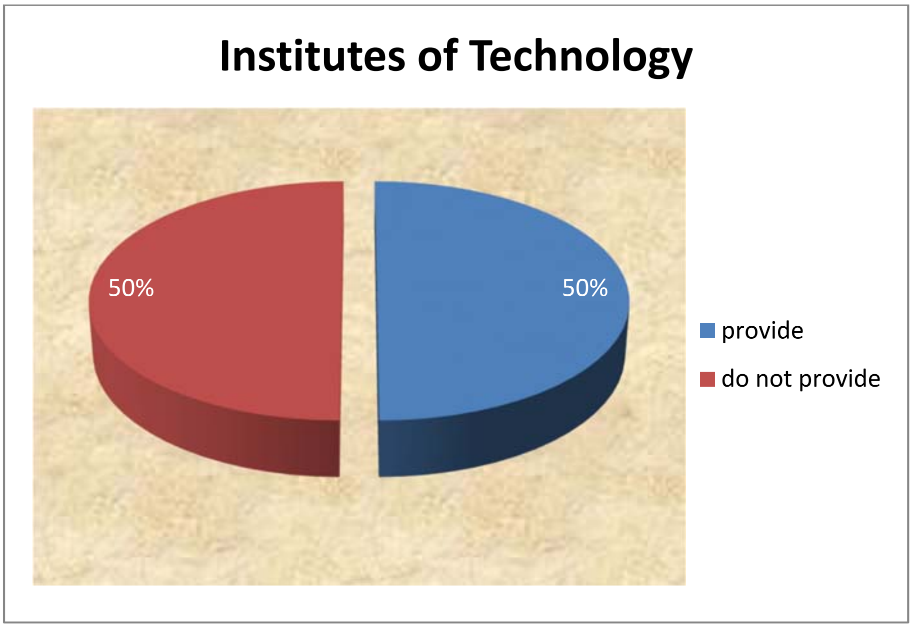


Fig 4.4 Ratio of Irish higher-level programmes that provide non-generic health and safety information exclusively for geodetic engineering surveyors



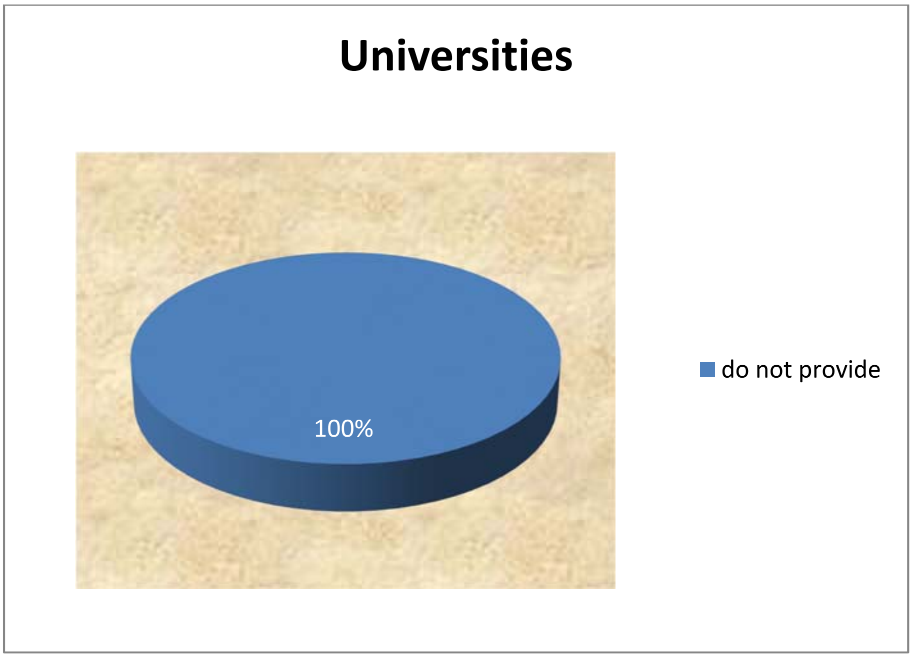
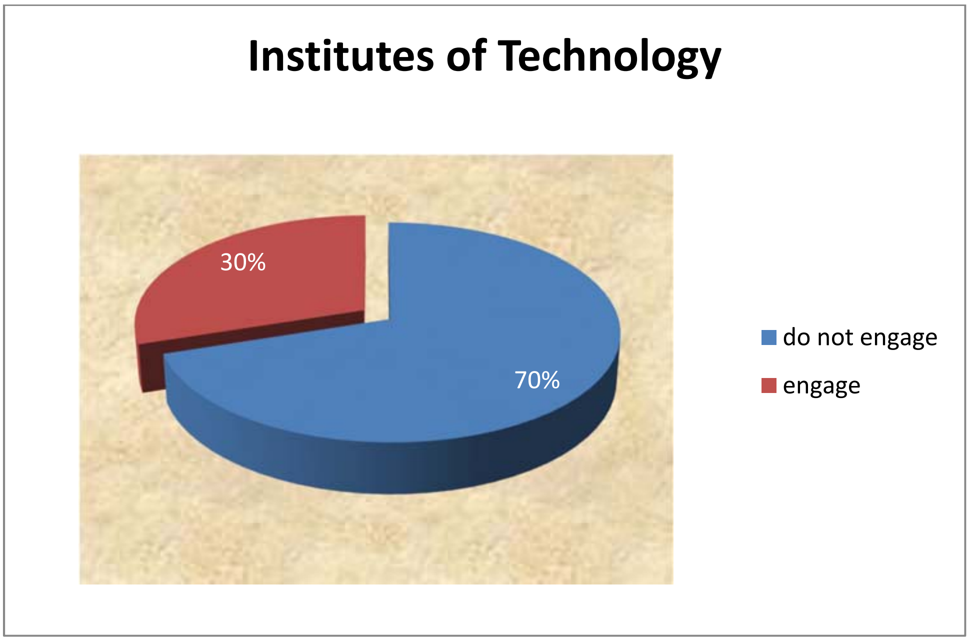


Fig 4.5 Ratio of students that engage in work placement programmes with geodetic engineering surveyors



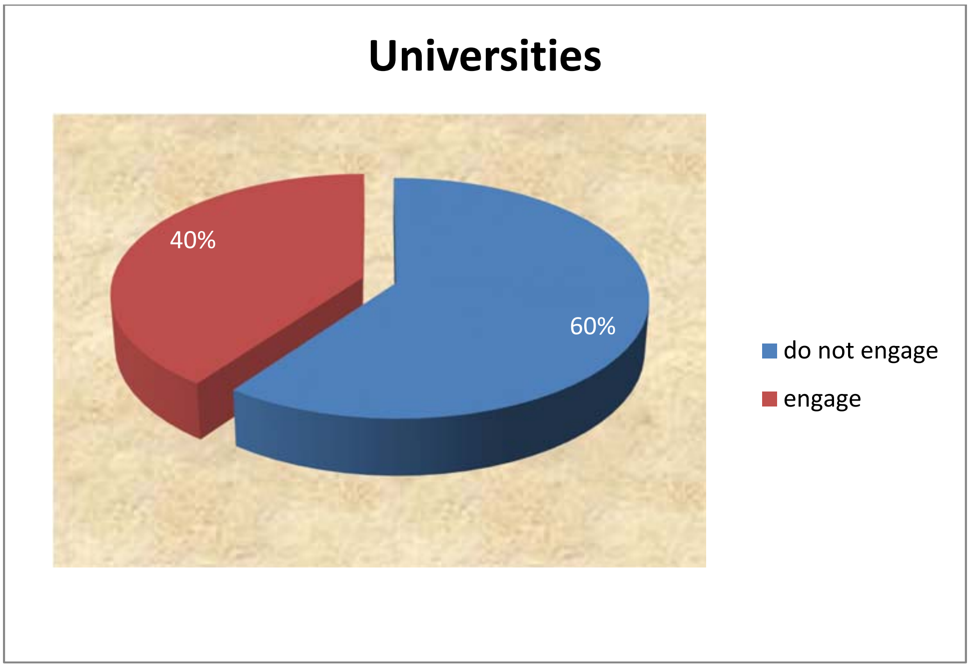
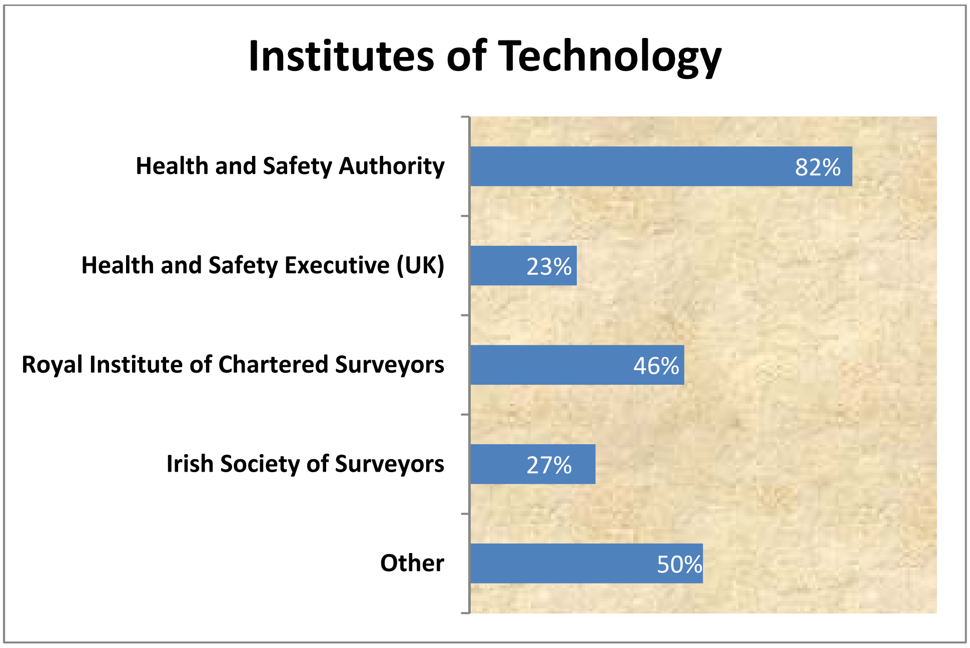


Fig 4.6 Organisations which students are being advised to consult if they require specific health and safety information for geodetic engineering surveying



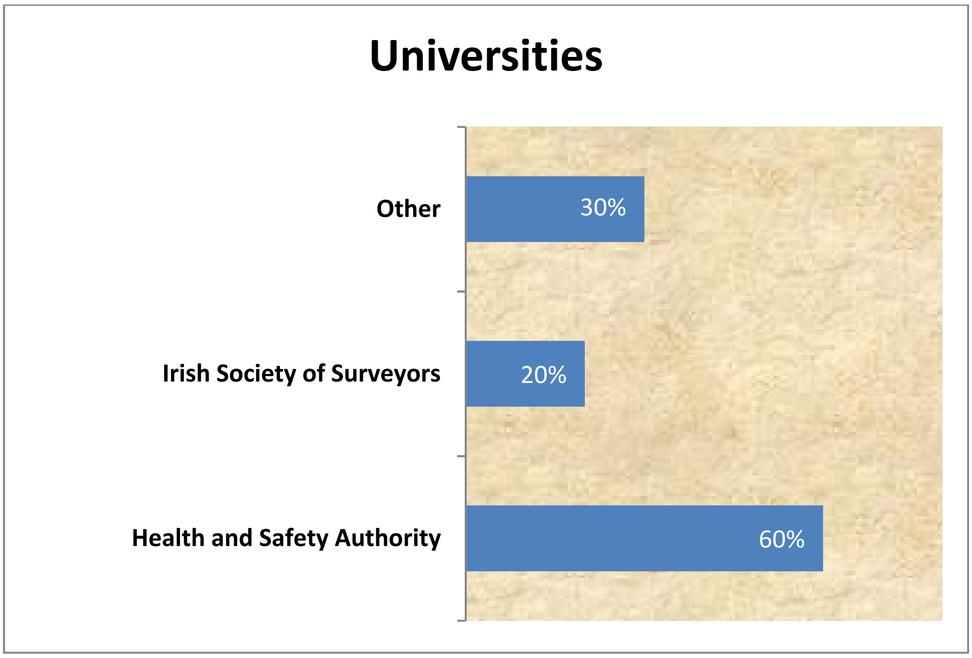
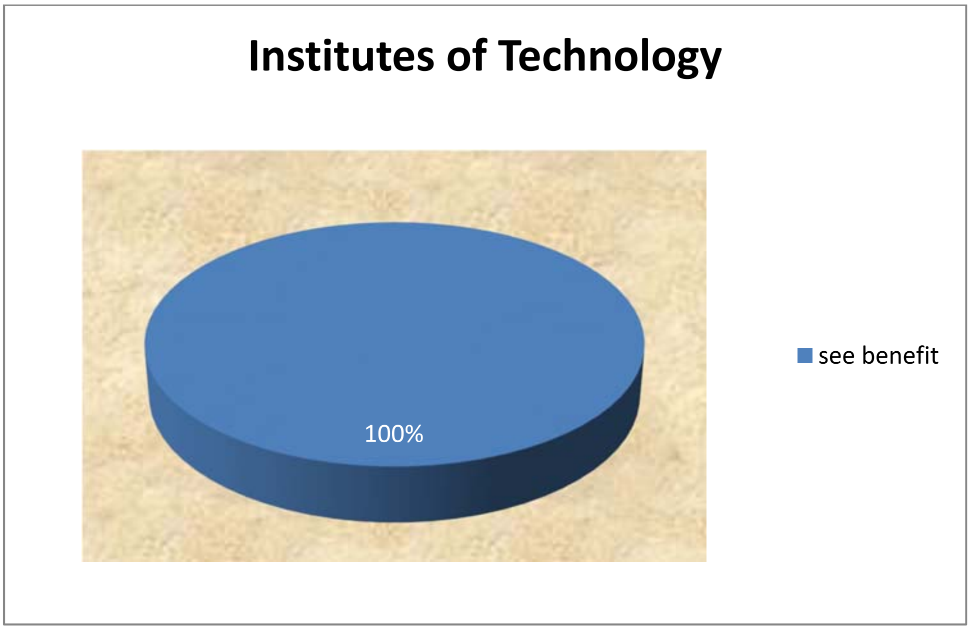


Fig 4.7 Ratio of respondents who believe the development of a Safe System of Work Plan (SSWP) would be beneficial for the Irish GES profession



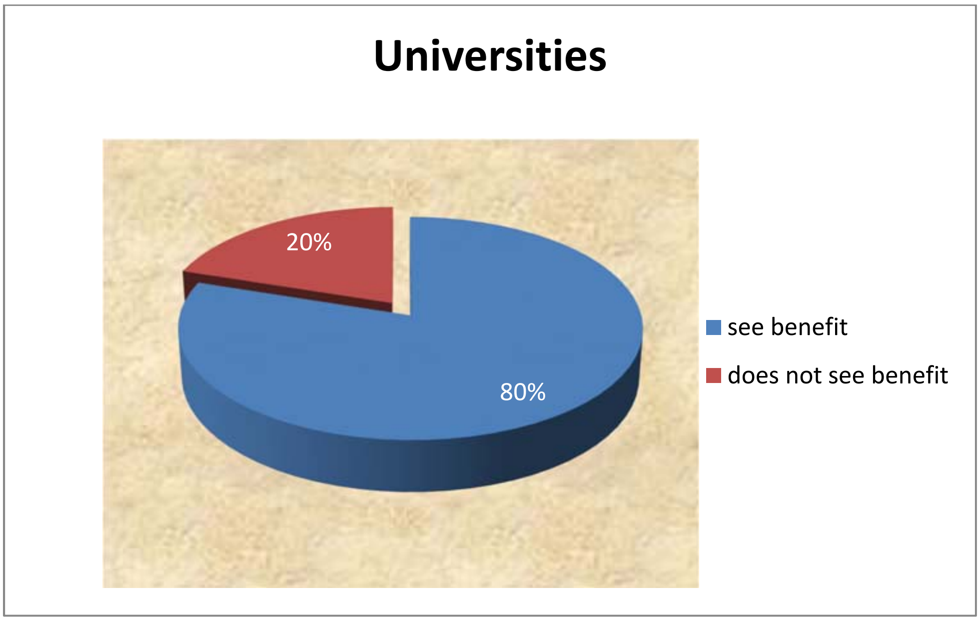
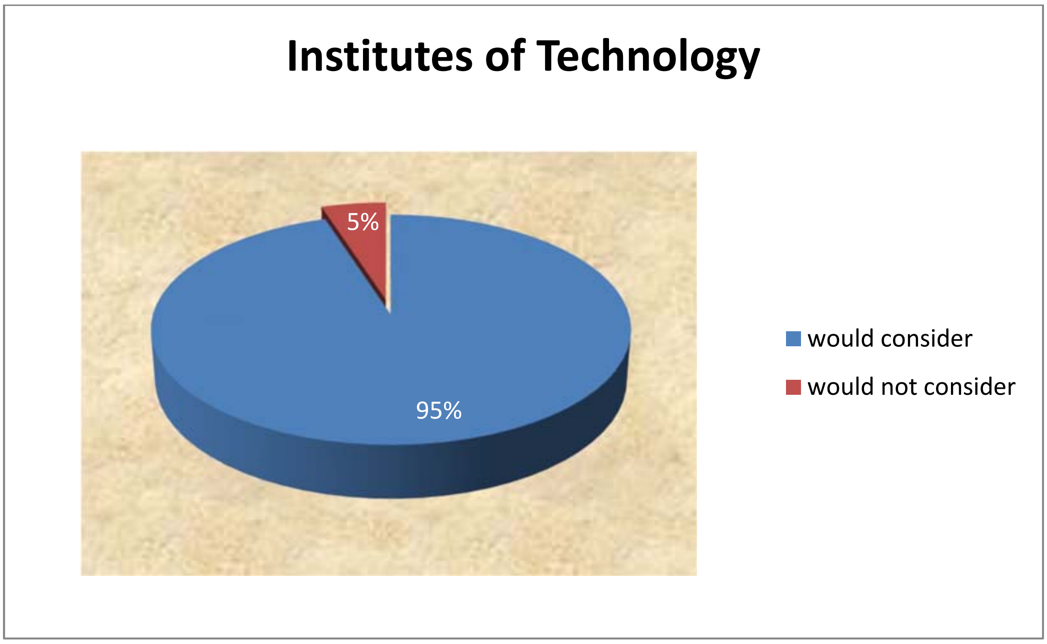


Fig 4.8 Ratio of respondents who would consider integrating an SSWP into their Irish academic programmes if one was developed



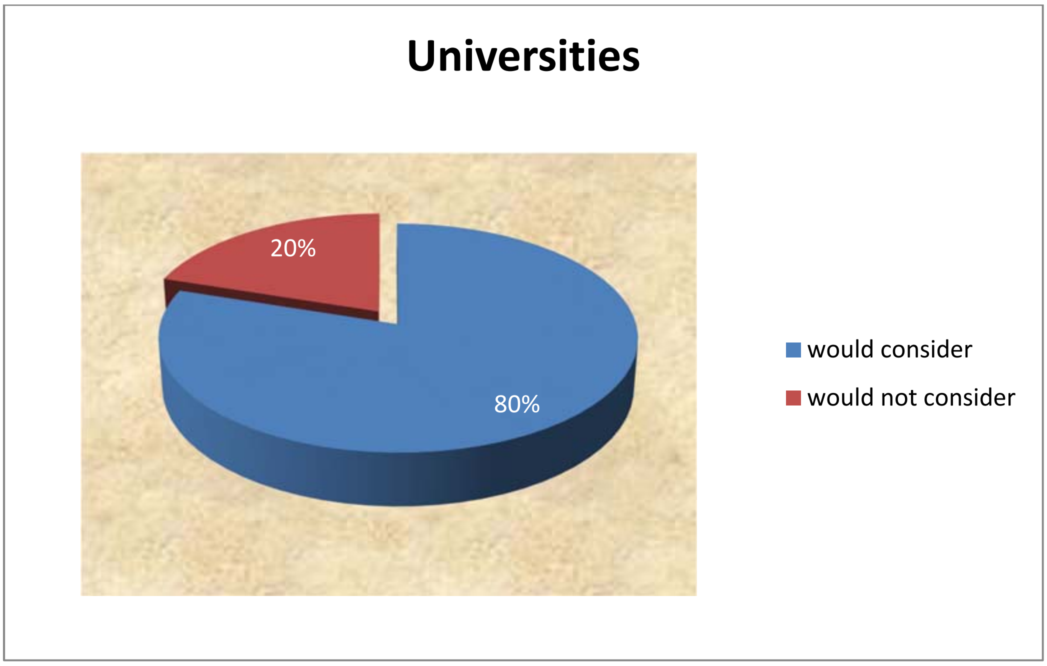
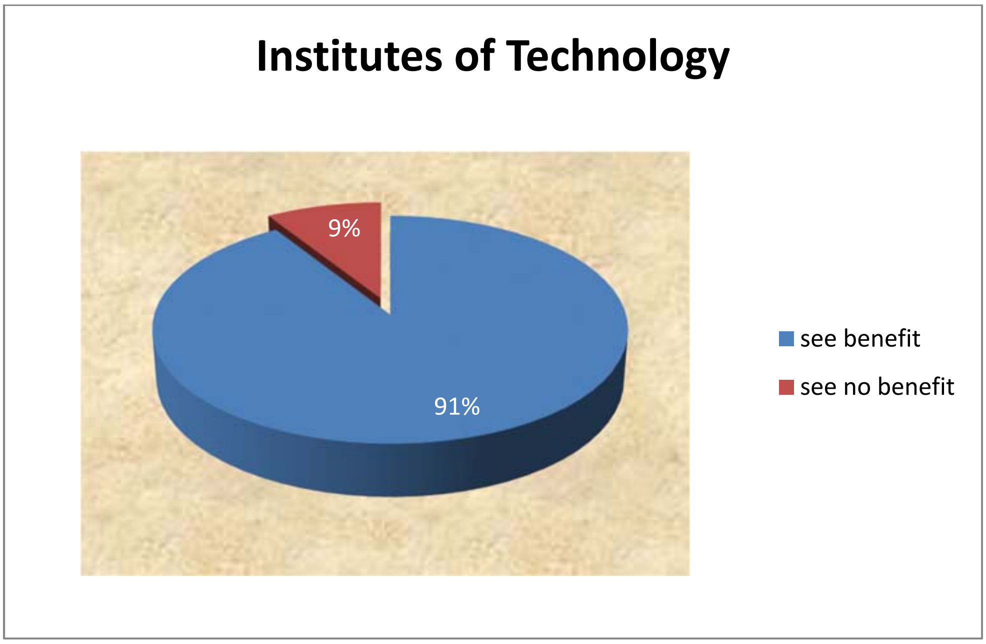


Fig 4.9 Ratio of respondents who believe the development of a health and safety *Code of Practice* for the Irish GES profession would be beneficial



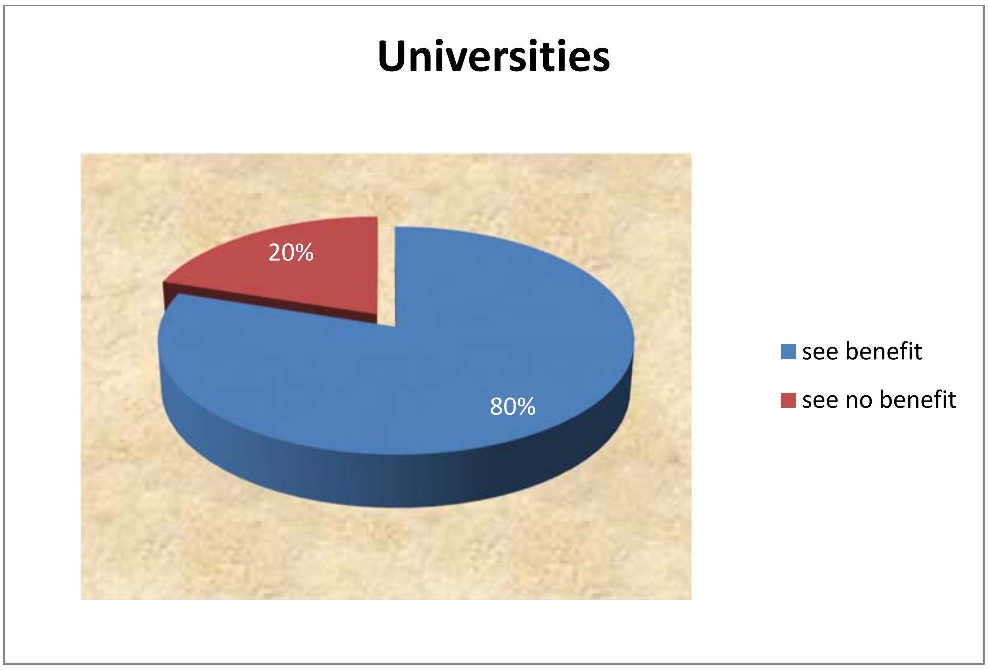
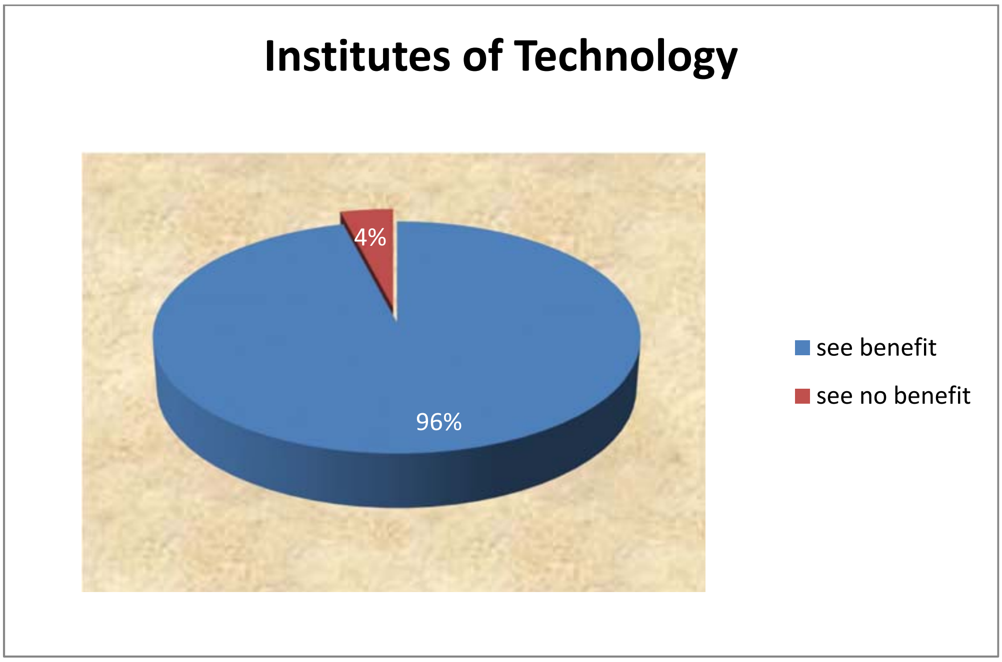


Fig 5.0 Ratio of respondents who believe a Construction Skills Certification Scheme (CSCS) for the Irish GES profession would be beneficial if introduced in the Republic of Ireland



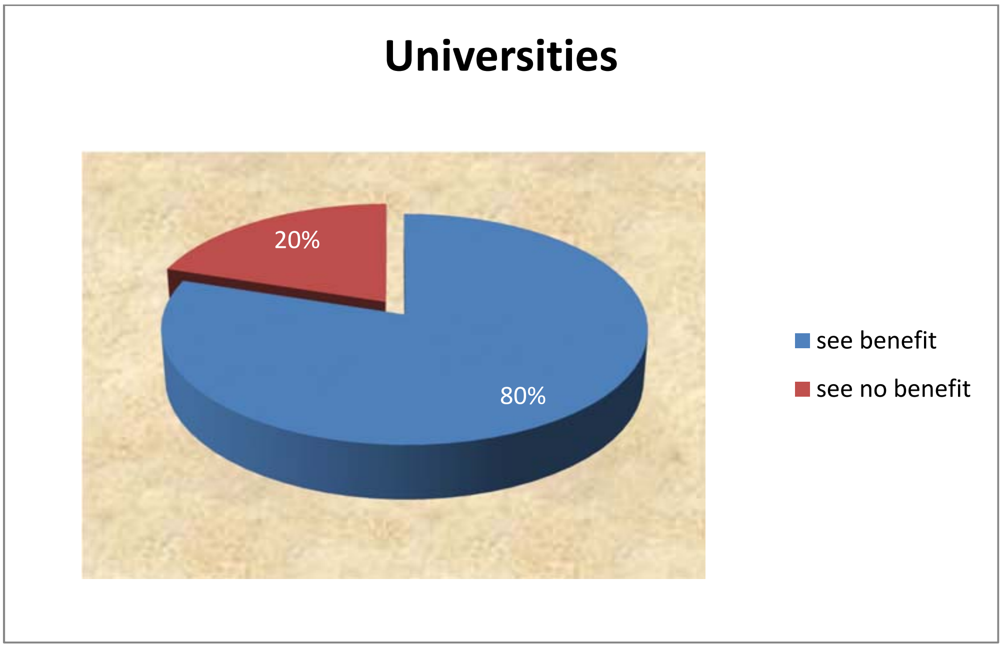
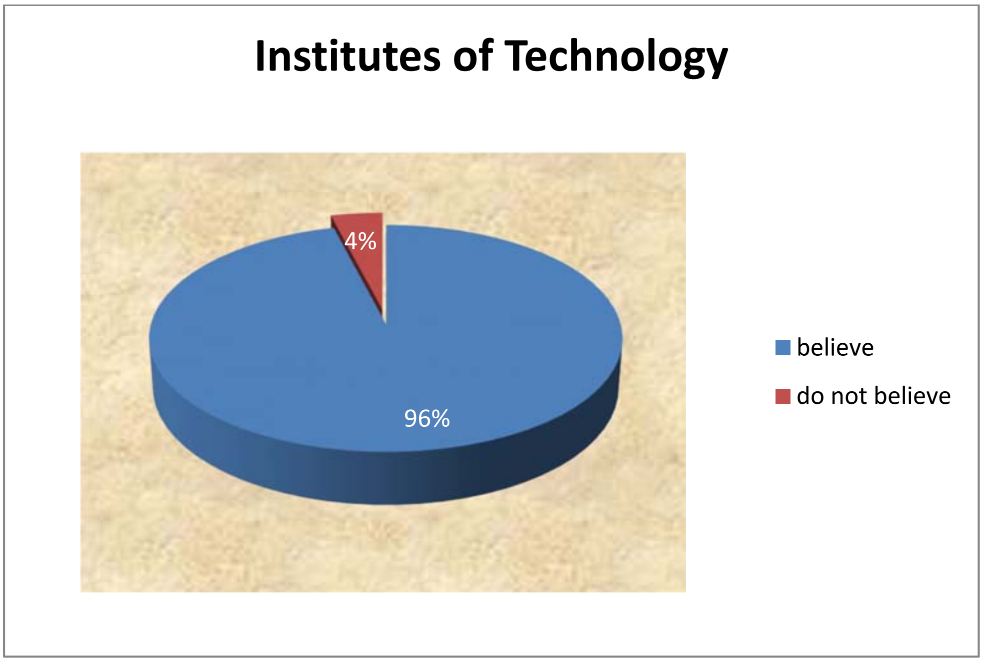


Fig 5.1 Ratio of respondents who believe that the Irish GES profession is an integral part of the construction sector



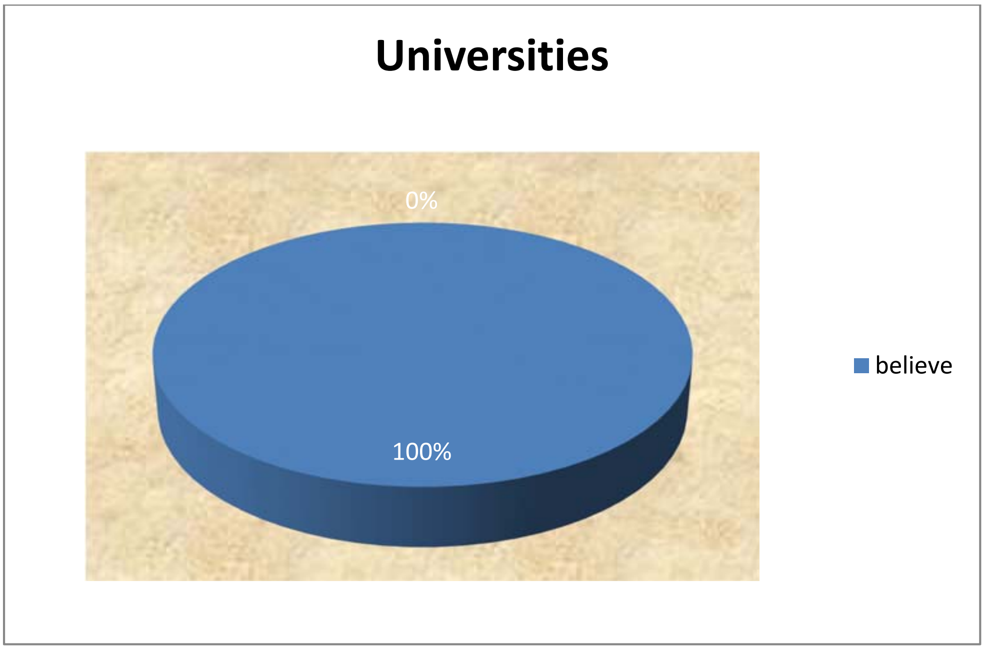
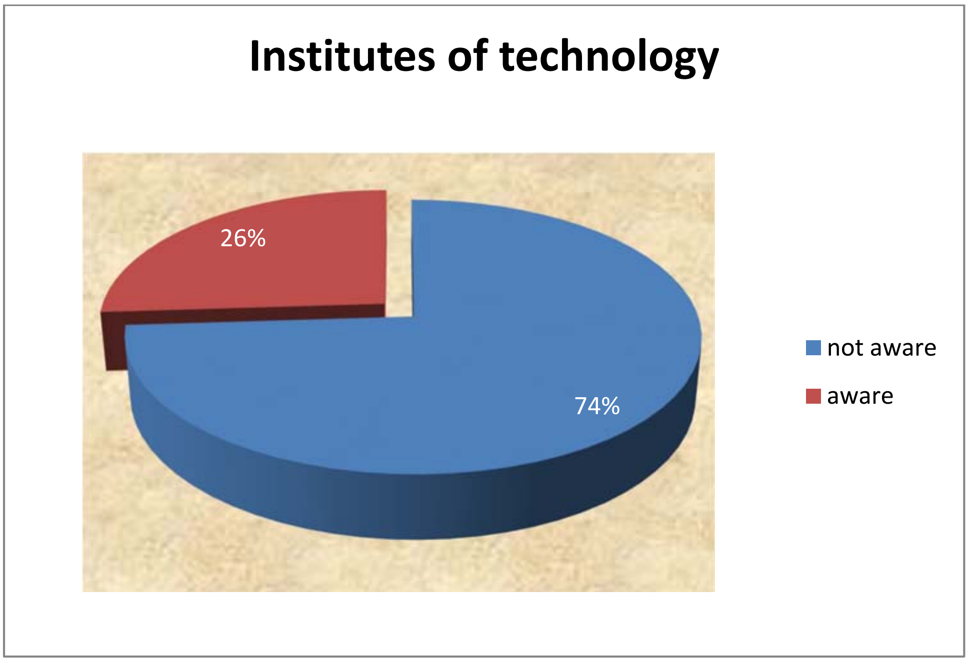


Fig 5.2 Respondents awareness of the exclusion of site surveying from the definition of what constitutes *construction work* within the Safety, Health and Welfare at Work Construction Regulations



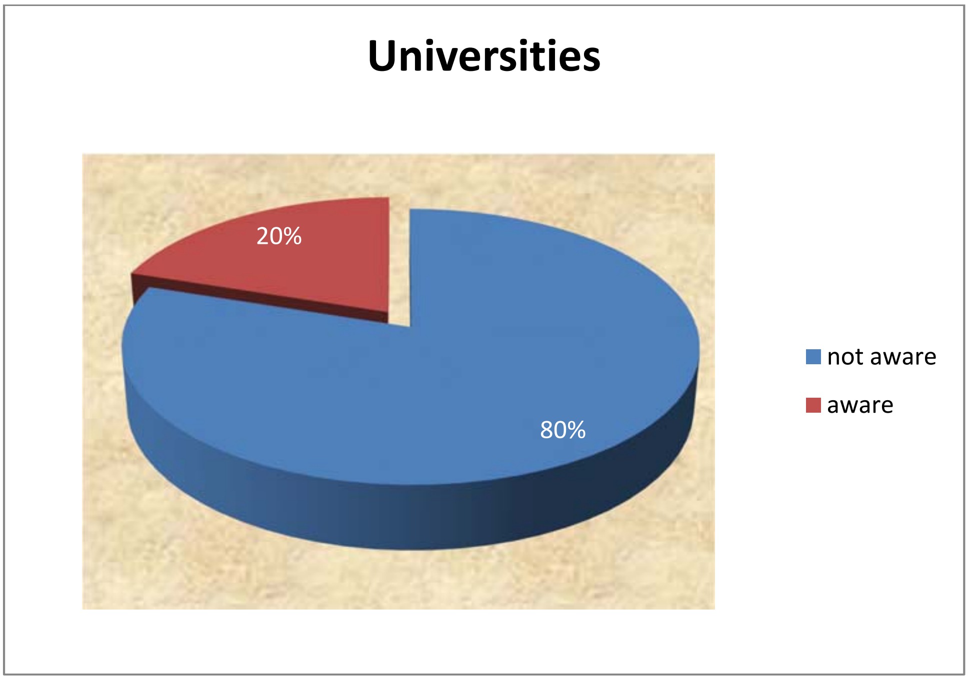
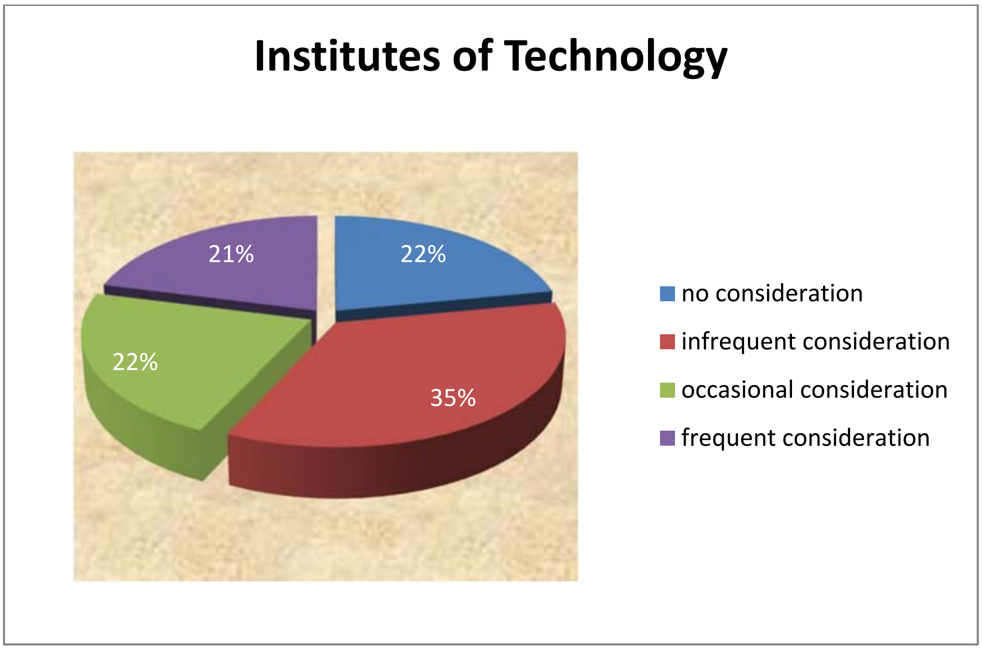


Fig 5.3 Respondents' level of consideration given to the occupational health and safety of geodetic engineering surveyors prior to completion of the questionnaire



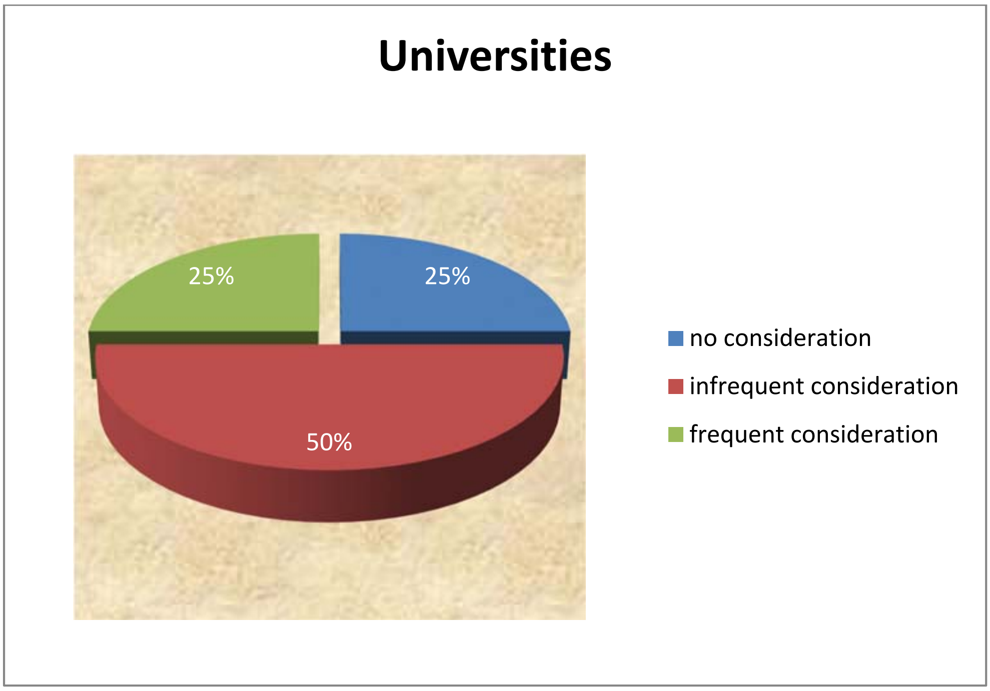
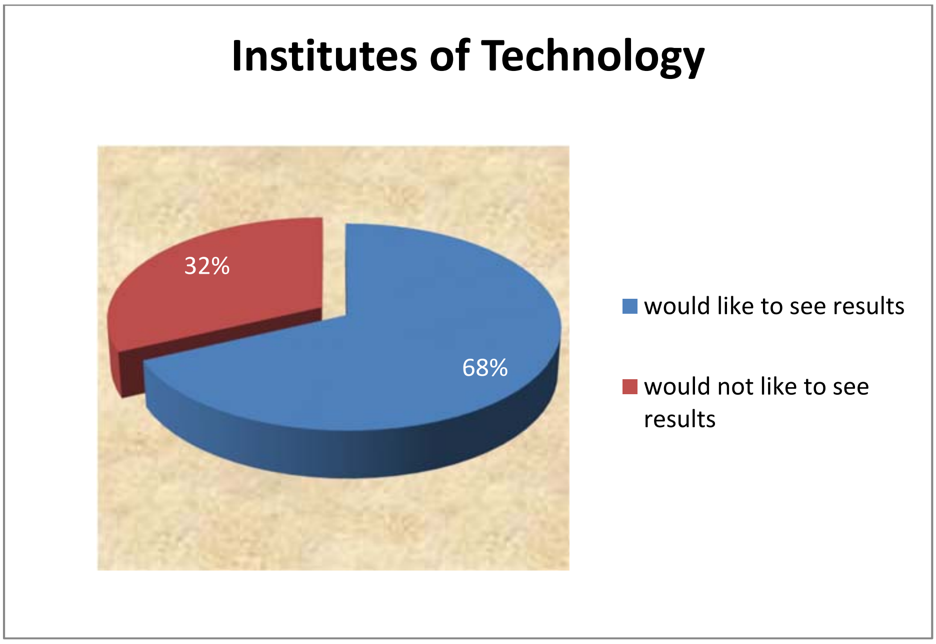
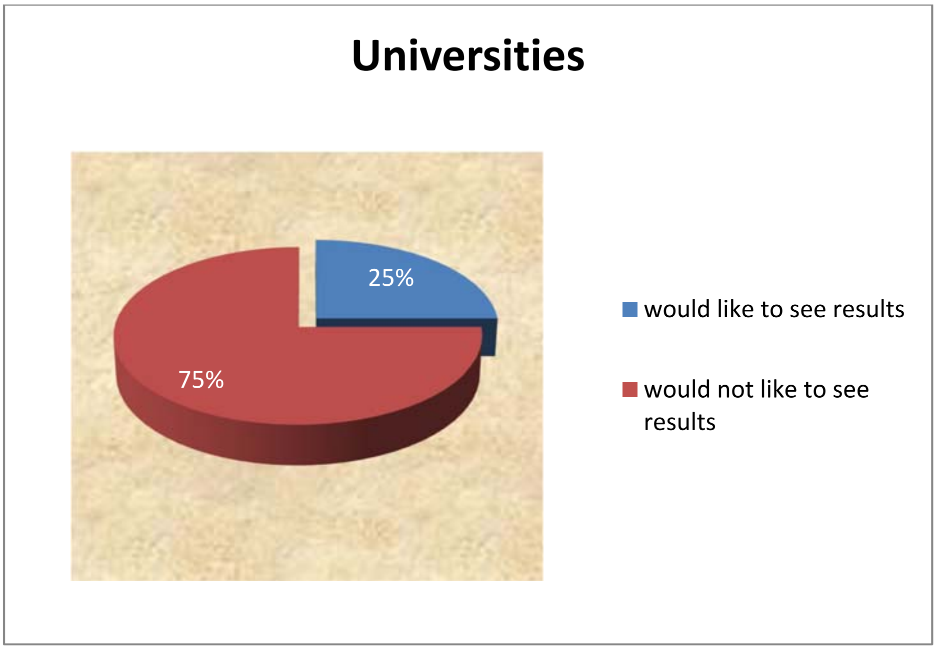


Fig. 5.4 Respondents who would like to see the overall results of this research





CHAPTER EIGHT

Discussion

The aim of this chapter is to critically evaluate the results from the survey and consider their meaning in the context of the research study. Discussing the feedback question by question is the best way to achieve this aim. Before this can be done, it may be helpful to remind the reader of the original research posit. Therefore, ex hypothesi, *a significant amount of occupational health and safety is not taught on the majority of higher-level geodetic surveying courses*.

Paradoxically, both support for and refutation of this theory can now be claimed. This is because most geodetic engineering surveying (GES) courses do contain some tuition in health and safety (therefore there is a *majority*, albeit a narrow one at +5% for Irish courses); nevertheless, this tuition has been found to be of short duration, very much generic and not specifically aimed at geodetic engineers, thus supporting the claim that effective teaching in the discipline of health and safety for this cohort is being greatly overlooked.

Such assertions were gleaned solely from the responses academics made to the survey, as feedback was found to contain a suitable measure of detail to enable assessment and comparison. Participants seemed not to encounter many problems in undertaking the research, confirmation of which can be found in the high rate of completion (83% from universities; 93% from the institutes of technology). Equal to this was the high rate of response (69%), which was sufficient to make a valid inference of the overall GES higher-level education system in Ireland. This suggests that the methods used in the survey were correctly chosen and implemented.

In relation to the analysis, the narrative on the following pages debates the main issues.

Q1. ***Average number of graduates per year?***

Respondents reported that in Ireland there are on average 1500 students[113] graduating each year from courses that contain tuition in geodetic engineering surveying. Any number of these graduates may commence work in the field, and anecdotal evidence would suggest that the figure could be high.[114] This strengthens the case for safety intervention, especially when the strong correlation between youth and workplace accidents is considered.[115]

Q2. ***Approximate ratio of graduating males to females?***

Responses from this question indicate that GES is a highly gender-specific field of learning, with 78% of all students being male. By itself, this statistic has considerable implications given the strong association between males and workplace accidents.[116] However, the negative association is further deepened when the youth referred to above is again considered. This is because the prevalent working demographic has now become young *males*. Consequently, the need for safety intervention grows even more apparent in the sector.

Q3. ***Is occupational health and safety taught on the programme?***

In answer to this question both universities and institutes proved similar, with 50% of the former reporting tuition in the discipline, and 60% of the latter. When both providers are collectively considered, just over half of all higher-level GES

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[113] The reader should be heedful that this figure represents those that participated in the survey and not the entire sample frame. The true figure is likely to be substantially higher.
[114] Past research has shown that employment in the GES field is a popular choice for young engineers (Muskett, 1995).
[115] See the European Agency for Safety and Health at Work Factsheet EN 70: *Young Workers: Facts and Figures – Exposure to Risks and Health Effects* (2007) for a brief synopsis.
[116] See the European Agency for Safety and Health at Work Report: *Gender Issues in Safety and Health at Work* (2003*b*) for a more detailed overview.

programmes are providing tuition in matters relating to occupational health and safety. The survey did not allow for respondents to expound on reasons for this; however, a past research study in an associated area by Lee (1999) found analogous deficiencies. In this instance evidence was put forth that suggested a lack of confidence on behalf of lecturing staff in the teaching of health and safety, the widespread view that the discipline is not an academic concept, and the fullness of most curricula. Congruently, Symonds (2001), in a slightly later report, speaks of the inclusion of health and safety within curricula not being supported by heads of departments and in many cases not being recognised as an intellectual branch of learning. In this instance it was also found that curricula are too full to allow the inclusion of a significant amount of tuition, and the subject is frequently provided by existing staff, with many not possessing the necessary competence to carry out the role. Such statements reverberate more recently in the work of Stacey, Simpson and Schleyer (2009), who also found that not all academics see the benefit of risk education and suggest that convincing them of the merit would be a complex task. Their views are also in concert with those of Lee and Symonds in relation to the fullness of most programmes, and they agree that this is one reason why integration of the discipline is often found to be low or inadequate.

Regardless of the explanation, it must be remembered that at the highest European level there is a continuous call for health and safety to be embedded into all higher-level educational programmes.[117] Yet, when it comes to the education of geodetic engineering surveyors, evidence from this investigation indicates that in many cases such calls remain unanswered.

[117] See European Agency for Safety and Health at Work (EU-OSHA) 2010 report: *Mainstreaming Occupational Safety and Health into University Education* for an in-depth overview.

Q4. ***Are the occupational health and safety classes a component of a module or a standalone module?***

Overall, the provision of health and safety as a standalone module was found to be low. Over 79% of institutes and 67% of universities reported that when the discipline was taught, it was only offered as a component of a module. As a consequence, the feedback largely concurs with the earlier findings of Lee in 1999, Symonds in 2001, and Healy, Kelly, Turner and Townsend in 2011.

Those not conversant with the principles of health and safety may from the outset argue that this is a negative finding, primarily owing to the possibility of students viewing the discipline as less important than that of a detached module. In actuality, this may not be the case, as debate can be raised in relation to whether the subject is more effective when amalgamated into a battery of modules—hence forming an underlying theme of the programme—or as a once-off standalone module. In evaluating this discussion one must pause to consider delivery strategy, as the point can be cogently argued that there is little use in providing a full module in safety and health during the first year of a four-year course and not subsequently revisiting the topic throughout the remainder of the programme. Yet, on the other hand, how do those responsible for higher-level programmes ensure safety is a thematic undercurrent of all subjects?

Regardless of such a debate, the crux of the dispute should lie in which method delivers the best education for GES students. As this is an argument containing well-founded claims from both those in favour and those against a standalone module, no clear decision can be made. Therefore, perhaps the most logical solution would be to have safety as a standalone subject and also incorporated as a primary theme in all practical subjects, thus embedding the discipline firmly into the students' education.

Q5. ***If occupational health and safety is a component of a module, approximately how many hours are spent teaching the subject?***

When health and safety is offered as a study option, GES students attending institutes of technology spend less time studying this discipline than their counterparts at university.

However, study times in both were found to be brief. For instance, 61% of programmes in institutes of technology do not exceed 11 hours of learning, whilst 67% of universities only spend between 21 and 30 hours studying the discipline.[118] Such findings raise the question: what duration of study is enough to give students a solid grounding in concepts of occupational health and safety? The answer is by no means clear-cut. Factors such as a student's previous knowledge, the occupational risk associated with the profession they seek to enter, and the ability of lecturers to teach the subject all have to be taken into account. For the GES student these factors weigh heavily. Evidence from Chapter Four has shown that students' knowledge of health and safety prior to higher-level education may be poor, as the discipline is not being taught at primary and post-primary levels in Ireland. Chapter Five demonstrated a considerable and clear indication of the hazards a surveyor encounters. And historically, Lee (1999), Symonds (2001), and Stacey, Simpson and Schleyer (2009) have all called into question most lecturers' competence when it comes to teaching health and safety. When considered collectively, these factors

[118] The latter figure may seem like a substantial duration of time, but over a four-year programme it could be as little as five hours per year.

would suggest that the study times revealed in this investigation seem exceptionally low.

Q6. ***If occupational health and safety is a standalone module, how many ECTS credits are assigned to the subject?***

On average, both universities and institutes of technology report a five-ECTS credit weighting for the tuition of health and safety. Such a figure can be regarded as low when one considers that a four-year degree may comprise 240 ECTS credits. However, it is nearly an exact parallel of Healy, Kelly, Turner and Townsend's (2011) research, which examined honours degree programmes and found, on average, that less than 2% of available ECTS credits (4.8 credits) were allocated to health and safety. Despite this, it should be noted that these researchers found—albeit statistically outliers—values as high as 30 ECTS: allocations that were simply not found in Irish GES programmes.

Q7. ***Are the occupational health and safety classes elective or mandatory for students?***

The vast majority of respondents from the institutes (79%) and 100% from the universities stated that such classes were mandatory. Universities therefore seem to have placed the discipline on a slightly stronger footing. Nevertheless, findings from both educational providers are encouraging, as they show a degree of significance being placed on the subject of health and safety.

Q8. *In addition to general occupational health and safety information presented on the programme, is there any particular information given on health and safety issues exclusively for geodetic engineering surveyors?*

This question goes further than the simplicity of earlier enquiries by asking if there is anything other than generic health and safety tuition being offered to GES students. Answers garnered raise serious concerns in relation to the preparedness of graduate geodetic engineering surveyors to enter the workforce. This is because only 50% of institutes report offering such tuition. However, the real concern lies in the fact that although the provision by institutes is considerably low, it is high when compared to universities, 100% of which reported that there is no specific GES health and safety tuition. Such a finding may leave the reader debating whether generic health and safety tuition is really good enough or if students need specific information on how to control the intrinsic hazards of their profession. Given the claims made throughout this thesis and in the case study from Chapter 5, one must concede that non-generic tuition is required, yet, in the majority of cases, this is not what is happening.

Even in the small number of cases where respondents state that information on health and safety exclusively for GES students is presented, certain caveats remain. This is due to the question seeking clarification as to whether '*...any particular information [was] given...*' The use of the word 'any' therefore implies that even an ad hoc, fleeting reference by a lecturer to GES health and safety could constitute tuition. Consequently, to explore this question more thoroughly, different research approaches such as semi-structured interviews (to see what exactly is being taught) and focus groups (to benchmark organisations against each other) are needed. This, however, should be regarded as a secondary concern, as the primary focus must remain not on what is being taught in the minority of cases, but on what is not being taught in the majority of cases.

Q9. ***Do students ever go on work placement with geodetic engineering surveyors?***

Given that nearly 65% of respondents declared that students do not engage in work placement, this experience does not seem to be a significant factor in this profession's higher-level education. This is somewhat surprising, as Young, Murphy and Smith (2010) are adamant the GES employment market takes a pluralistic view, seeking graduates that have a combination of intellectual capabilities and also practical work experience. However, the premise of such a debate is digressing from the central theme of this study by focusing on employability over education. Returning to the focus of tutelage in health and safety, such a finding has both negative and positive implications. In addressing the negative, students for whom a structured work experience placement was not a feature of their higher education have not experienced mentoring and closely supervised GES work, and their first encounter upon graduation may be a role that has all the demands of a full employment post. If health and safety has not hitherto been adequately covered, the individual will be forced to rely only on their instinctive ability to act safely. In contrast, the positive aspect of not engaging in work placement is the prevention of harm—even if only short-lived—because if students have not been taught the fundamentals of health and safety at higher level, then why take the risk with a work placement? Undoubtedly, this is a myopic outlook and one that does nothing for the long-term care of the students, but it does draw attention to the fact that employing an inexperienced worker even for a short duration of time is a significant concern, especially if they do not have even a basic understanding of the fundamentals of occupational health and safety.

Q10. ***If a student required specific health and safety information for geodetic engineering surveying, which source(s) would you advise them to consult?***

As a result of a certain degree of insolent behaviour on the author's behalf, collectively, the responses to this question demonstrate that those tasked with providing higher-level GES tuition have inadequate knowledge of what health and safety advisory services exist. For instance, 71% of respondents stated that they would advise students to consult the Health and Safety Authority for specific GES safety information. In discussions with the Authority, it confirmed that it neither has, nor ever had, any information specifically for geodetic engineering surveying. To remedy this problem, a concerted effort should be made by either the aforementioned advisory service or an external research group to develop, and promote, better health and safety education in this branch of learning. Of course, the success of such an initiative would hinge on academics' willingness to utilise such services, so the survey was designed to allow – and in an act of contrition on the author's behalf – for this theme to be explored in the next four questions.

Q11. ***Safe Systems of Work Plans (SSWP) are now commonplace in the construction industry. Do you think an SSWP for geodetic engineering surveyors would be beneficial?***

In response to this question, 100% of institutes of technology indicated that they would see benefit in the development of SSWPs, and 80% of universities were also in agreement. Such high levels of preference therefore provide the rationale for the system. Moreover, given that in recent years SSWPs have been successfully created for an ever-increasing number of diverse occupations (graveyard and cemetery operations, monument maintenance, road working, demolition, etc.),[119] it does seem possible that one could be developed for the GES profession.

Q12. *If an SSWP was developed for geodetic engineering surveyors, would you consider integrating its content into your programme?*

If the answers to the last question suggest that academics saw benefit in the development of an SSWP, then the answers to this question attest to why one should be created. This is because 88% of respondents declared that they would consider integrating the system into their higher-level teaching, thus documenting the evident niche in this educational market. In itself, this is unsurprising, as Lee, as early as 1999, found that the majority of lecturers' competence varies in relation to health and safety, and most would welcome more source material and training opportunities. The practicality of implementing such a system for this demographic would also be relatively straightforward due to the fact that SSWPs have in the past been delivered through e-learning and a web-based depository, mediums that would undoubtedly suit the academic community.

Q13. *In your opinion, would the development of a health and safety Code of Practice for the geodetic surveying profession be beneficial?*

A total of 86% of respondents answered *yes* to this question. In recent times the Health and Safety Authority has dramatically increased its publishing in this area,

[119] All of the aforementioned SSWPs have been developed by the Health and Safety Authority in Ireland since 2005, and their effectiveness has been recognised both nationally and internationally, viz., Taoiseach's Award for Excellence in Public Service in 2008; IMHOTEP Award, International Social Security Association in 2006.

with codes being established for roof work, quarries, agriculture, forestry, forklifts and the installation of anchors, to name but a few. As a result, the Authority seems well placed to develop such a provision for the GES sector. Nevertheless, development could come from other agencies such as the Irish Society of Surveyors or the Royal Institute of Chartered Surveyors, or indeed an independent research group. However, as this study only sought feedback from academics and not industry, antecedent analysis of the market is needed to establish the feasibility of such a document.

Q14. ***In the UK, a Construction Skills Certification Scheme (CSCS) is in operation. This scheme offers skill cards to geodetic engineering surveyors and chainmen following completion of a prescribed course on issues that include safety. Do you think such a scheme would be of benefit for these occupations in the Republic of Ireland?***

Nearly 80% of university respondents and 96% of respondents from the institutes of technology agreed that such a scheme would be of benefit. Strictly speaking, however, they were not the ideal target population for such a question, as it would have been better posed to those based in industry. This is because CSCS training is strongly redolent of workplace learning as opposed to higher learning. Despite this, anecdotal evidence would suggest that there are instances of higher-level programmes providing students with the opportunity to avail of such training (more often than not this is limited to the Safe Pass programme), therefore a response from academics was deemed to be valid.

In relation to the likelihood of a skills card being implemented, if past performance is an indication of future potential it is highly unlikely to be introduced in this country without a paradigm shift in the manner in which the CSCS operates. At present, there are only 24 categories of skills cards, a figure that is vastly behind the UK's 220.

Q15. ***Do you consider the geodetic engineering surveying profession to be an essential component of the construction sector?***

Unsurprisingly, 98% of respondents deem this to be the case. By itself this figure does not prove much, as it is an entrenched view of those that understand the construction process. The responses do, however, serve to illustrate the absurdity of the fact that surveying is excluded from the definition of what constitutes *construction work* in current health and safety regulation.

Q16. ***Are you aware that the Safety, Health and Welfare at Work (Construction) Regulations exclude site surveying from the definition of what constitutes 'construction work'?***

As a follow-on from the last question, this question attempted to examine the respondents' awareness of the exclusion. The results demonstrate that 80% of university staff and 74% of staff from the institutes of technology were not aware. Such significant ratios suggest two things: firstly, respondents to this survey were candid, even when their responses portrayed them in a somewhat negative light.[120] And secondly, due to lecturers misconstruing the legislation, there is potential to convey to students a false sense of relevance concerning the regulatory Instrument. As a result, students may wrongly form the opinion that their occupational wellbeing is being protected in regulatory format. To remedy this problem, corrigenda to the

[120] If the same is true for the rest of the survey, this would imply that a high degree of value can be placed on the feedback, as it suffers from minimal social desirability bias.

legal text should be made to include the GES profession, and in the interim steps need to be taken to inform the wider academic community of this deficiency.

Q17. ***Please indicate on the following scale approximately how much consideration you have given to the occupational health and safety of geodetic surveyors prior to the completion of this questionnaire.***

In response to this question, the majority of respondents stated that they gave infrequent consideration to the occupational health and safety of GES professionals. By raising the topic through the medium of this research, it is hoped that this may change. Nevertheless, the responses demonstrate that, at present, the majority of academics are giving little thought to the profession's health and safety. This may be a result of any number of reasons, but available evidence from past investigations (Young, Murphy and Smith, 2010) suggests that many academics simply teach the way they were taught. Given that occupational health and safety only came to prominence in relatively recent times,[121] older academics may simply not have been taught the subject or stayed abreast of the recent changes. Moreover, the same may be true for a number of younger academics who studied GES in Ireland, as awareness of the discipline has, if anything, greatly increased in recent years, yet the findings from this survey have highlighted many instances where health and safety is still not taught.

[121] See Barrington, D. (1983) *Report of the Commission of Inquiry on Safety, Health and Welfare at Work.* PL.1868 for what many regard as the genesis of modern-day health and safety in Ireland.

Q18. ***Thank you for taking the time to complete this questionnaire. There now follows a section for any comments you may have.***

This segment allowed respondents to convey their personal thoughts on both the survey and the research topic. As expected, support was drawn from some but contention from others. Overall, the most detailed feedback came from the institutes of technology and a far more laconic response was received from the universities. Positive comments included:

‘*I would be very interested in seeing the results*’

‘*It's an interesting area and one that I will now have in mind when teaching surveying*’

‘*Now that I think of it, I can’t believe it’s not considered more*’

‘*...we would be interested in your findings when they become available*’

‘*...a really well designed questionnaire...*’

However, there were also some rather negative comments such as:

‘*Why should geodetic engineers be any different from anyone else on a construction site?*’

‘*What’s dangerous about their work?*’

‘*Is this really all necessary?*’

Nevertheless, in summary, there were far more responses in support of the research than those that were against.

Q19. ***Please indicate if you would like to see the overall results of this research when completed:***

The majority of respondents from the institutes of technology (68%) declared that they would, while in contrast only 25% of university respondents confirmed an interest. This could suggest greater interest can be found in the topic of GES health and safety amongst institute of technology staff. However, it is also possible that the majority of respondents from universities were simply not interested in this particular research study.

Overall, based on the high rate of response and the detail of the feedback received, the survey can be regarded a success, as in the context of the overall research project, it served to clearly illustrate the evident problems in this sector.

The next chapter will present the overall conclusions of the investigation and actionable steps that can be taken to remedy some of the issues raised.

CHAPTER NINE

Conclusions and Recommendations

In accordance with the original aim of this research, the previous eight chapters have presented the findings from an investigative study into the health and safety education of geodetic engineering surveyors in the Republic of Ireland. In doing so, the five initial objectives (p. 5 and 6) have also been met. Although the principal conclusions can undoubtedly be formed from the results of the empirical survey and subsequent discussion in the preceding chapter, there is merit in revisiting some of the seminal points from earlier in the thesis.

Chapter Two outlined the genesis of the geodetic engineering surveyor by chronicling the role from times of antiquity to present day, thus demonstrating how this technical profession has always been at the vanguard of shaping the built environment, and helping the reader conclude that due to its enduring status is worthy of research. From there, Chapter Three established that the levels of tutelage a surveyor can expect to obtain while studying the subject in Ireland vary considerably. This is largely due to rudiments of the discipline being amalgamated into a host of academic subjects of varying structure and duration. One possible explanation for this may be the lack of licensure requirements in the Republic of Ireland. For comparative purposes, preceding and contemporary international practices were documented. Having done this it can be concluded that Ireland's problems are not diametrically opposed to those of many other countries, as there is a growing body of international research that points to the recognition of the need to renovate surveying curricula. Of course, the converse is also true, and there are numerous programmes that have been deemed to be performing satisfactorily. However, there can be little controversy in concluding that the majority of courses are challenged to manage the swift nature of change in this technological field of study, and as a consequence, there was a clear rationale for research in this area.

Chapter Four focused on a literature review of the health and safety educational provisions available to geodetic surveyors from a young age up until they enter the workforce. This was done to provide a comprehensive overview of a surveyor's educational attainment in the discipline of health and safety. As a result, from the *Primary School Level Review* it can be concluded that health and safety as a standalone subject remains excluded from the curriculum.

Concerning post-primary pedagogy in matters relating to health and safety, the discipline does permeate a diverse range of subjects across the curriculum; however, as a standalone topic it remains excluded. Furthermore, in nearly all instances of health and safety tuition being offered to students, it is contained within subjects that are non-obligatory.

When it comes to addressing higher-level programmes, as one ought to expect, courses differ greatly due to students not following a prescriptive state-regulated format of study, so it is unfeasible to try to form a collective conclusion on what is taught or not taught. In relation to the specific focus of higher-level geodetic engineering surveying programmes, no previous studies were in existence that examined the health and safety content; however, peer research from germane areas (construction and engineering) highlighted great disparity in the teaching of the subject matter. In addition, Chapter Four provided a forum for a discussion on training requirements relating to geodetic surveyors, while illustrating a number of judicial decisions that have been made concerning those found not to have been afforded adequate health and safety instruction. This enables the reader to conclude that transgressions in the area of occupational health and safety can, and often do, result in punitive sanctions. A peripheral argument was also made about concerns with both the FÁS Safe Pass and the Construction Skills Certification Scheme

(CSCS) training programmes, from which it was concluded that certain anomalies are present. The chapter also reviewed legislation from the Oireachtas and the Irish Statute Book specifically aimed at the education of geodetic engineering surveyors. Here it was found that there are few laws relevant to the profession and that such negation is not indicative of the other surveying occupations, primarily due to both the Building Control Act 2007 (S.I. No. 21 of 2007) and the Recognition of Professional Qualifications Regulations 2008 (S.I. No. 138 of 2008) clearly outlining the levels of education required to allow use of the designations 'Quantity Surveyor' and 'Building Surveyor'. Such a finding adds credence to the call for licensure, as its implementation would mean that only appropriately trained and educated surveyors could practise. In addition, Chapter Four specifically centred on the text of the Safety, Health and Welfare at Work Construction Regulations. Here it was found that the instrument purposefully excluded the profession of surveying from its clauses, and as a consequence, it can be concluded that surveyors' occupational wellbeing is at greater risk due to their health and safety not being protected in regulatory format. From there, Chapter Five demonstrated the hazards and potential maladies of one particular group of geodetic engineering surveyors through the medium of a case study. Having taken this empirical approach it can be concluded that there is a risk to the occupational health and safety of the profession, as mutable hazards were found to be associated with each of the three surveying tasks analysed. In short, hazards from the physical, mechanical, ergonomic, chemical and psychosocial categories were all discovered. Nevertheless, despite addressing such a considerable aggregate, this study in no way conclusively illustrated the entire spectrum of dangers a surveyor may encounter. Had the research setting not been restricted to a civil engineering environment and instead been broadened to include a building or structural surveying setting, it seems fair to assume a far wider array of hazards may have been revealed. With this in mind, one can only conclude that the profession's higher-level education should incorporate a significant amount of tuition in health and safety due to the at-times perilous nature of the work.

When the kernels of each chapter are collectively considered, there is a catalogue of reasons why a surveyor's higher-level education should contain adequate levels of health and safety tuition. Nevertheless, as we have seen from the feedback of higher-level educators in Chapter Seven, this is not always the case. And so perhaps the research's primary contribution to knowledge is that the standard of health and safety tuition varies greatly on Irish geodetic engineering surveying programmes: for some it's a total lacuna, for others a bare minimum, whilst for more it's a considerable element. For student surveyors this non-uniformity can only translate to uncertainty in relation to whether they will graduate and enter the workforce educated in the discipline or be required to gain their first experiences of protecting both their own and their peers' occupational wellbeing in an industry that statistically has been one of the most dangerous in Irish society. Given that Allan (1995) dramatically claims the '*total range of services provided by the geodetic surveying profession is vital for the continuance of modern civilisation as we know it*', reliance on the latter possibility seems ill-advised.

In relation to steps that can be taken to improve this position, there are a number of recommendations:

1. Licensure of the geodetic engineering surveying (GES) profession would force educators to provide programmes of a set content and duration. If this were to happen, it is felt that the subject of health and safety would stand a

better chance of being included. However, this study does not recommend outright the implementation of licensing, as before this can occur, further research and consultation with stakeholders is needed to determine if the benefits would be tangible and result in better integration of the discipline without producing adverse effects on the profession.

2. Regardless of the debate concerning licensure, given the failure of a considerable number of academic programmes to include health and safety in their curricula, serious consideration needs to be given to embedding the subject across all GES programmes. To promote the need for this, academic directors should be made aware of the results of this study. In addition, the Health and Safety Authority's Third Level Education Group (TLEG) needs to be informed of the findings, as they have the ability to encourage better integration of the discipline.

3. Legislation in the guise of the Safety, Health and Welfare at Work Construction Regulations 2013 should be amended to take account of the GES profession. In times of economic regrowth, an argument may be made that additional health and safety legislation is not conducive to economic recovery and prosperity. However, this is only in reference to oppressive, draconian legislation. In this instance, recommendations are not of the former variant but instead are merely advocating the inclusion of the GES profession into regulations that already encompass nearly every other construction profession.

4. Given the established hazards, the dearth of relevant published literature and clear support for the development of safety educational aids (Safe System of Work Plans, Code of Practice, etc.), a strong case can be made for additional investigative research in this area with the view to developing such aids.

In many instances these recommendations, although of sound value, would require a cadre of support to implement. Proposed changes to the licensure of an entire profession, repeals and amendments to the very purview of legislation, and the approval of industry codes of practice are not tasks that could ever fall within the remit of an autonomous research project. As a consequence, it is now at the discretion of external parties to determine how the presented recommendations can be actioned.

Nevertheless, the fourth recommendation does correlate directly with an opportunity for further research within the scope of this study. This extension of research, which is both exploratory and remedial, offers the chance to produce a tangible output and is discussed in the final chapter.

CHAPTER TEN

Development of a SSWP for Geodetic Engineering Surveyors

10.1 Introduction

In looking to remedy the problem of inadequate health and safety tuition for GES students, challenges exist. Full higher-level curricula, the dearth of relevant published literature, varying levels of knowledge of the discipline among academics, and a general unawareness of the hazards facing GES practitioners are among the many reasons why higher education courses are struggling to impart sufficient health and safety tuition. Yet, there is clear support from the academic community to develop safety educational aids. As highlighted in Chapter Seven, such aids could take the form of a pictogram-based safe system of work plan (SSWP). Feedback from academic respondents demonstrate that, in principle, such a system would be approved by 100% of Irish institutes of technology and 80% of universities that teach geodetic engineering surveying, while 88% of academic respondents said they would consider integrating an SSWP into their higher-level teaching if one were developed.

The practicalities of implementing such a system for this demographic would be relatively straightforward, because SSWPs have in the past been delivered through e-learning and a web-based depository — formats that would undoubtedly suit the academic community. Moreover, the last ten years have seen a proliferation in construction-related SSWPs developed by the Health and Safety Authority (HSA) in diverse areas such as house building, civil engineering, demolition, and commercial building, and in various individual tasks such as monument maintenance and graveyard digging. Their effectiveness has been recognised both nationally and internationally, viz., the Taoiseach's Award for Excellence in Public Service in 2008 and the Imhotep Award from the International Social Security Association in 2006.

The HSA (2015) describes the primary objective of SSWPs as to '*identify the major hazards associated with work activities and to ensure that appropriate controls are in place before work commences*'. Nevertheless, the documents are limited to a pictogram-based indication of the control measures, as shown in Figure 5.5 below. Based on this prompting representation, readers are required to determine that the control measures they have implemented are adequate and subsequently to tick the box to confirm.

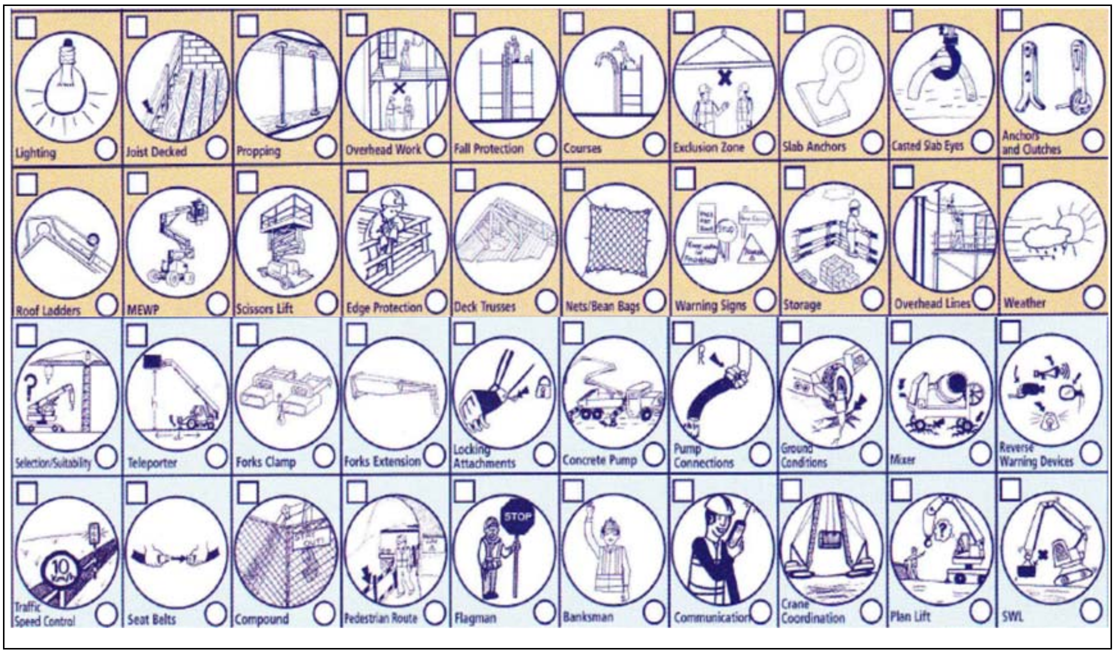
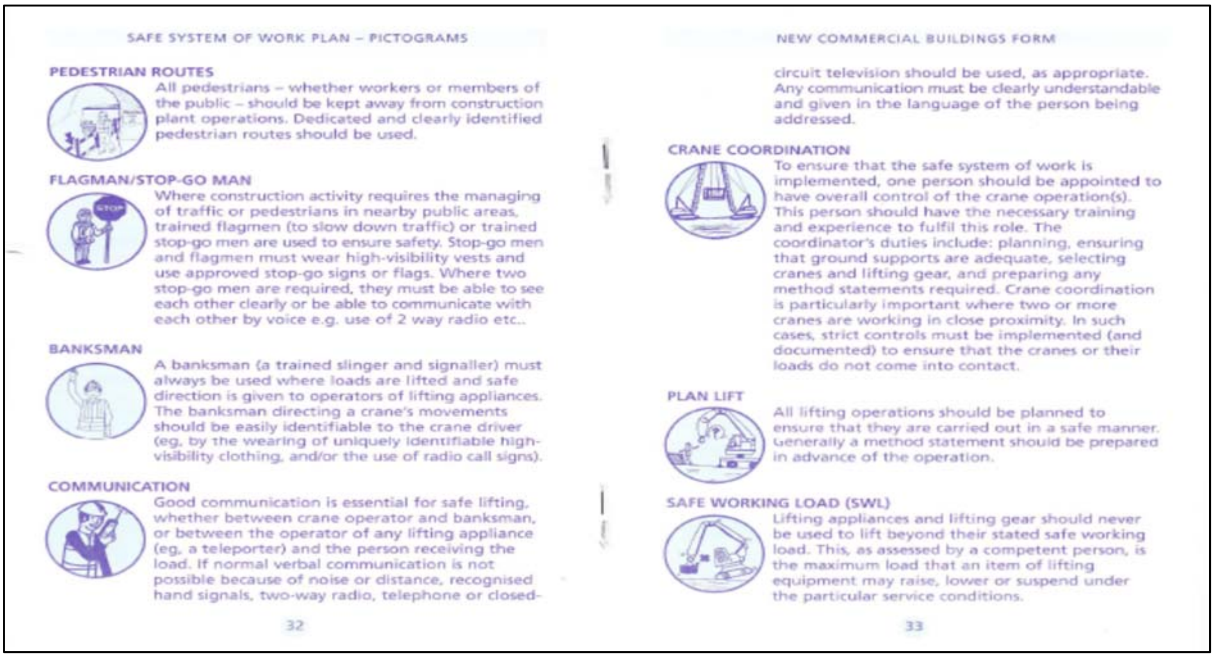


Figure 5.5 Extract from a Safe System of Work Plan for New Commercial Buildings

This, however, raises the nettlesome question of how readers can be expected to select, implement and determine the validity of health and safety control measures if they have never been educated on what such measures ought to comprise. To overcome this, the HSA publishes booklets to accompany SSWPs that explain the meaning of each pictogram, an example of which can be seen in Figure 5.6 overleaf.



SAFE SYSTEM OF WORK PLAN – PICTOGRAMS

PEDESTRIAN ROUTES

All pedestrians – whether workers or members of the public – should be kept away from construction plant operations. Dedicated and clearly identified pedestrian routes should be used.

FLAGMAN/STOP-GO MAN

Where construction activity requires the managing of traffic or pedestrians in nearby public areas, trained flagmen (to slow down traffic) or trained stop-go men are used to ensure safety. Stop-go men and flagmen must wear high-visibility vests and use approved stop-go signs or flags. Where two stop-go men are required, they must be able to see each other clearly or be able to communicate with each other by voice e.g. use of 2 way radio etc..

BANKSMAN

A banksman (a trained slinger and signaller) must always be used where loads are lifted and safe direction is given to operators of lifting appliances. The banksman directing a crane's movements should be easily identifiable to the crane driver (eg. by the wearing of uniquely identifiable high-visibility clothing, and/or the use of radio call signs).

COMMUNICATION

Good communication is essential for safe lifting, whether between crane operator and banksman, or between the operator of any lifting appliance (eg. a teleporter) and the person receiving the load. If normal verbal communication is not possible because of noise or distance, recognised hand signals, two-way radio, telephone or closed-

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NEW COMMERCIAL BUILDINGS FORM

circuit television should be used, as appropriate. Any communication must be clearly understandable and given in the language of the person being addressed.

CRANE COORDINATION

To ensure that the safe system of work is implemented, one person should be appointed to have overall control of the crane operation(s). This person should have the necessary training and experience to fulfil this role. The coordinator's duties include: planning, ensuring that ground supports are adequate, selecting cranes and lifting gear, and preparing any method statements required. Crane coordination is particularly important where two or more cranes are working in close proximity. In such cases, strict controls must be implemented (and documented) to ensure that the cranes or their loads do not come into contact.

PLAN LIFT

All lifting operations should be planned to ensure that they are carried out in a safe manner. Generally a method statement should be prepared in advance of the operation.

SAFE WORKING LOAD (SWL)

Lifting appliances and lifting gear should never be used to lift beyond their stated safe working load. This, as assessed by a competent person, is the maximum load that an item of lifting equipment may raise, lower or suspend under the particular service conditions.

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Figure 5.6 *Safe System of Work for New Commercial Buildings — Explanatory Booklet*

Such booklets underpin the entire process and provide the basis for an ensuing SSWP, since development of an SSWP is a straightforward process that requires only organisation of the resulting pictograms into an appropriate sequence. For this reason, it has been decided to make evident the content of such a booklet for the GES profession as this will provide formative safety material that could be commercially developed to make up a working SSWP.

10.2 Methodology

The hazard list and supporting pictograms were drawn from Chapter Five's (p. 90) case study on the occupational hazards of geodetic engineering surveying in a road construction environment. This case study employed a sequential task analysis that examined three primary GES tasks: establishing land made available, setting out, and levelling. Contained in these three tasks were 15 subtasks comprising 23 hazards that could negatively affect surveyors' occupational health and safety (To facilitate the reader, Table 1.3 is reproduced below).

Table 1.3 *Sequential Task Analysis*

TASK 1: ESTABLISHING LAND MADE AVAILABLE (LMA)	ASSOCIATED HAZARDS (H)
1. The surveyor determines what areas of LMA must be established before arriving at the works location	None identified
2. The surveyor arrives on site and begins establishing LMA	**(H.1A)** A surveyor carries all the equipment necessary for establishing LMA **(H.1B)** The surveyor works alone **(H.1C)** The surveyor walks long distances and stands for long periods of time **(H.1D)** The surveyor interacts with the surrounding environment **(H.1E)** The surveyor seeks welfare and sanitation services
3. The surveyor uses surveying instruments to set out LMA	**(H.1F)** GPS equipment is used
4. The surveyor determines the established co-ordinates	**(H.1G)** Vegetation is cleared **(H.1H)** Stakes are hammered into the ground
5. The determined position is highlighted	**(H.1I)** Spray paint is used
Task 1 is now complete	
TASK 2: SETTING OUT	**ASSOCIATED HAZARDS (H)**
1. The surveyor determines what areas of a site must be set out	None identified
2. Essential equipment is prepared	**(H.2A)** The surveyor cuts pins needed for setting out
3. Pins are loaded into a vehicle	None identified (due to task being performed by a general operative)
4. The surveyor drives to the location where setting-out work is planned	**(H.2B)** Carriage of surveying pins
5. The surveyor sets up a total station instrument	**(H.2C)** The surveyor uses a total station instrument **(H.2D)** The surveyor works near traffic
6. Control points are set out	**(H.2E)** Control points are hammered into place
7. Pins are set out	**(H.2F)** The surveyor works near plant and machinery

	(H.2G) Pins are hammered into place **(H.2H)** The surveyor uses a digging bar **(H.2I)** Projecting rebar becomes evident
Task 2 is now complete	
TASK 3: LEVELLING	**ASSOCIATED HAZARDS (H)**
1. The surveyor determines what pins must be levelled	None identified
2. The surveyor uses a dumpy level	**(H.3A)** Anatomical misalignment while using a dumpy level **(H.3B)** A second surveyor uses a measuring staff. Manholes are dipped **(H.3C)** Measurements are taken in excavations **(H.3D)** Work at heights is performed
3. The surveyor generates hazards for other parties working on site	**(H.3E)** Grading teams are forced to pull string lines and take dip levels
Task 3 is now complete	

For the purpose of this chapter, all 23 hazards are discussed, but to form a working SSWP, typically more than 100 hazards would need to be documented. For a GES safe system of work plan this can be achieved by carrying out a similar case study on additional projects other than road construction, for example structural, commercial, residential, or industrial developments. Further hazards would then undoubtedly become apparent and thus contribute to an SSWP's development.

In determining the most appropriate control measures, the quintuple approach of statutory regulation, established best practice, manufacturer's recommendations, regulatory guidance, and expert consultation was used to document the remedying controls.

10.3 SSWP: Hazards and Controls

H.1A: Carrying Equipment

Associated Risk(s)	Controls Required
Risk 1: Musculoskeletal damage due to manual handling of loads	1, 2, 3, 4, 5, 6, 7
Risk 2: Slips, trips, falls due to loads being carried	8, 9, 10, 11, 12, 13
Risk 3: Physical anatomical stress due to load weights	1, 2, 3, 14, 15

Control Measures:

1. Organisational measures must be taken to reduce the need for manual handling.
2. Mechanical/ergonomic aids must be used where possible.
3. Loads to be carried should be matched to surveyors' physical characteristics and attributes (age, height, weight, strength, etc.).
4. All surveyors that are required to carry such equipment should undergo a recognised manual handling training programme, refreshed at intervals not exceeding three years.
5. Surveyors must at all times take necessary steps to avoid overreaching and excessive twisting of the lumbar region.
6. Surveyors with a prior history of back injury should be suitably accommodated.
7. Appropriate personal protective equipment should be worn (gloves, boots with reinforced toecaps/soles, etc.).

8. Walkways must be kept clear and free from obstruction.
9. Openings, excavations, unguarded edges, etc. should be suitably highlighted.
10. Sufficient lighting should be available.
11. Carried loads must never be positioned so as to restrict a surveyor's vision.
12. Routes of passage should be suitable planned, highlighted, and communicated.
13. Footwear should be suitable for ground conditions (anti-slip coated soles).
14. Adequate rest periods must be organised and taken.
15. Measures should be taken to ensure surveyors do not suffer from physical/heat exhaustion.

Corresponding Picture Representation:

H.1B: Lone Working

Associated Risk(s)	Controls Required
Risk 1: Physiological injury (accidents, medical incidents, violence, etc.)	1, 2, 3, 4, 5, 6, 7
Risk 2: Psychological injury due to isolation	8, 9

Control Measures:

1. Organisational measures should be taken to reduce the need for lone working in extremely isolated areas.
2. Lone working should not take place in areas known for anti-social behaviour, dangerous animals, gatherings of water, etc.
3. Surveyors intended routes and forecasted times of departure and arrival should be agreed and communicated with site management.
4. Surveyors should carry appropriate means of communication (cellular phones, walkie-talkies, whistles, etc.).
5. Surveyors for whom lone working makes up a significant proportion of their work should be trained in the principles of self-administered first aid and carry an appropriate first aid kit.
6. Surveyors engaging in lone work in isolated areas should have appropriate personal protective equipment in the form of weatherproof clothing and carry an adequate supply of food and water.
7. In order to reduce violence and aggression, agreement should be sought from landowners prior to entering or surveying any property.

8. Surveyors engaged in lone working who feel they are suffering the effects of isolation should make themselves known to site management. Site management in turn must offer appropriate interventions.
9. Site management must be vigilant for surveyors suffering the effects of isolation and pay particular attention to surveyors who fall into the category of a sensitive risk group (young, old, inexperienced, pregnant, etc.).

Corresponding Picture Representation:

H.1C: Walking Long Distances and Standing for Long Periods of Time

Associated Risk(s)	**Controls Required**
Risk 1: Overtaxing of the body leading to an exhaustive state	1, 2, 3, 4, 5, 6

Control Measures:

1. Mechanical means of transport should be used whenever possible.
2. Expected physical output should be matched to surveyors' physical characteristics and attributes (age, weight, strength, etc.).
3. Weather conditions should be monitored to ensure they are conducive to long periods of walking or standing.
4. The surveyors' clothing and footwear should be appropriate for the environmental conditions.
5. The provision of food and water should be made available or its consumption facilitated.
6. Adequate rest periods should be organised and taken.

Corresponding Picture Representation:

H.1D: Interacting with the Surrounding Environment

Associated Risk(s)	**Controls Required**
Risk 1: Adverse weather conditions	1, 2
Risk 2: Encroaching on animal habitat	3
Risk 3: Natural environmental features	4
Risk 4: Flora and fauna	5, 6

Control Measures:

1. Weather conditions should be monitored to ensure they are conducive to work (i.e. excessive wind, rain, sun, extreme temperatures, etc.).
2. Appropriate clothing for the forecasted weather condition should be worn.
3. Surveyors and site management should take all necessary measures to identify areas of animal habitat, especially those of hostile, wild or agricultural breeds, and take the necessary steps to avoid such areas.
4. Surveying near natural features such as bogs, marshes and rivers should be carefully planned and all necessary preventative measures put in place.
5. Measures should be taken to establish the type of vegetation that is present (hog weeds, nettles, briars, etc.) and protective measures implemented.
6. Remedying treatments should be available to counteract insect bites and stings.

Corresponding Picture Representation:

H.1E: Seeking Welfare and Sanitation Services

Associated Risk(s)	Controls Required
Risk 1: Lack of established welfare and sanitation services	1, 2, 3

Control Measures:

1. Organisational measures should be taken to establish mobile welfare and sanitation services. In instances where this is not possible, adequate time and means of transport should be provided to seek offsite welfare facilities.
2. Vehicles should carry stocks of antibacterial hand wipes and a supply of potable water.
3. Additional personal protective equipment should be worn in areas where agents that cause biological infection such as Weil's disease (leptospirosis) are thought to be present.

Corresponding Picture Representation:

H.1F: Used GPS Equipment

Associated Risk(s)	Controls Required
Risk 1: Surveyors sustaining an ocular injury due to the pointed antenna on GPS units	1, 2
Risk 2: Surveyors being exposed to lead from the GPS unit's power cords	3
Risk 3: Surveyors being exposed to excessive radio frequency waves from GPS units	4
Risk 4: Overheating of GPS unit's battery transformer resulting in fire	5
Risk 5: 220v charging of GPS battery units on a construction site	6

Control Measures:

1. The tip of the GPS antenna should be appropriately highlighted with a hi-visibility marking.
2. The GPS unit's antenna should be retracted when not in use and stored appropriately.
3. Due to the nephrotoxic and teratogenic properties of lead, all damaged power leads should be decommissioned and sent to an appropriate facility for repair or scrapping.
4. Due to GPS receivers emitting radio frequency waves (RF), surveyors should not come within 25 cm of the radio modem.

5. GPS battery transformers must never be covered by an obstructing material or article that does not allow heat to dissipate sufficiently from the batteries when charging.
6. Best practice in the construction industry dictates that only 110V power should be used onsite. As a consequence, all electrical charging of GPS batteries should be done offsite in a facility that has an appropriate 220V power supply.

Corresponding Picture Representation:

H.1G: Clearing Vegetation

Associated Risk(s)	**Controls Required**
Risk 1: Use of handsaws	1, 2, 3, 4, 5, 6, 7
Risk 2: Ocular injuries from protruding branches	8, 9

Control Measures:

1. Handsaws should only be transported in protective sleeves.
2. Surveyors should exercise caution when using an unguarded serrated sawblade.
3. Use of mechanical driven saws should only be considered if handsaws are not sufficient and surveyors are appropriately trained in their safe operation.
4. Saws should be sufficiently sharp to enable effective cutting.
5. Damaged saws should be removed from site and disposed of in a suitable manner.
6. Care should be taken when felling branches to ensure they do not cause injury to persons in the vicinity.
7. Measures should be taken to endure branches do not contain nests of swarming insects or other such animals before cutting.
8. Branches should be straight cut so as to leave no sharp edges, especial at face/eye level.
9. Eye protection should be worn when traversing through vegetation and when engaged in any cutting tasks.

Corresponding Picture Representation:

H.1H: Hammering Stakes

Associated Risk(s)	Controls Required
Risk 1: Surveyor accidently striking themselves with a sledge hammer	1, 2, 3, 4, 5
Risk 2: Strikes to underground services	6, 7, 8

Control Measures:

1. Sledge hammers should be of an appropriate weight for the user.
2. Sledge hammers should be of good construction and contain no defects.
3. Stakes should be pointed to allow smooth ground penetration and less hammering.
4. Adequate rest periods should be organised and taken.
5. First aid kits should contain dry ice bags for reducing swelling from impact injuries.
6. Efforts should be made to consult service drawings in an attempt to identify known underground hazards.
7. Cable avoidance tool (CAT) scanners should be used as necessary.
8. Authorisation permits-to-work should be developed and issued by site management as necessary.

Corresponding Picture Representation:

H.1I: Using Spray Paint

Associated Risk(s)	Controls Required
Risk 1: The substance is highly flammable (R11)	1, 2, 3
Risk 2: The substance is harmful if inhaled (R20)	4
Risk 3: The substance is injurious upon contact with skin (R21)	5, 6
Risk 4: The substance is a severe eye irritant	7
Risk 5: The substance can be harmful to ecological systems	8, 9, 10

Control Measures:

1. The substance must be kept away from sources of ignition.
2. Smoking is not permitted when using the substance.
3. Precautionary measures must be taken against static discharges.
4. Measures must be taken to avoid inhalation of the substance — use in well ventilated areas and wear appropriate respiratory protection if necessary.
5. Skin contact with the substance must be avoided — wear appropriate gloves if necessary.
6. Application of the product should be done through a hand operated line marking trolley where possible.
7. Wear appropriate eye protection at all times when applying the substance.
8. The substance should not be discharged into drains or watercourses.
9. Empty spray paint canisters should be recycled at an appropriate facility.

10. A copy of the product's safety data sheet should be retained on site and consulted as necessary.

Corresponding Picture Representation:

H.2A: Cutting Steel Pins

Associated Risk(s)	**Controls Required**
Risk 1: Incorrectly mounted cutting discs	1
Risk 2: Operatives sustaining lacerations during consaw operation	1, 2, 3, 4, 5, 6, 7
Risk 3: Operatives sustaining eye injuries during consaw operation	8
Risk 4: Operatives sustaining hearing damage during consaw operation	9
Risk 5: Operatives sustaining respiratory damage during consaw operation	10, 11
Risk 6: Refuelling of consaws	12, 13, 14, 15, 16, 17
Risk 7: Out-of-date cutting discs being used	18

Risk 8: Sparks being generated as a result of consaw operation	19, 20, 21
Risk 9: Operatives becoming entangled during consaw operation	22, 23

Control Measures:

1. Only operatives with abrasive-wheel training are permitted to mount or change abrasive cutting discs.
2. All necessary guards must be in place and in satisfactory working condition.
3. The consaw must never be drop-started.
4. The consaw must not be used with hands above head height.
5. The area where the consaw is being used must be free from other site operatives.
6. Operatives must inspect the consaw before starting it to ensure it is in safe operating condition.
7. The consaw must never be operated if damaged. Defects must be reported to site management.
8. Protective goggles must be worn during all consaw operating tasks.
9. Hearing defenders must be worn during all consaw operating tasks.
10. Respiratory protection must be worn if the material being cut emits dust.
11. When necessary, a consaw water attachment should be used to abate dust.
12. Fuel must be stored at a safe distance from the consaw's operating zone.
13. Refuelling should take place in designated areas away from access to watercourses or surface water drainage systems.
14. Additional PPE should be worn as necessary (gloves, protective eye glasses, etc.).

15. Smoking is not permitted during refuelling operations.
16. Spillages should be reported to site management.
17. Spill kits must be available and used when necessary.
18. Resin-based cutting discs older than 3 years must not be used.
19. Flammable material must not be stored in areas where consaws are operating.
20. Fire extinguishers should be available nearby.
21. Operative clothing must be kept free of flammable material.
22. Long hair must be suitably tied up.
23. Loose clothing or jewellery must not be worn whilst operating a consaw.

Corresponding Picture Representation:

H.2B: Transporting Surveying pins

Associated Risk(s)	Controls Required
Risk 1: Musculoskeletal damage due to manual handling of loads	1, 2, 3, 4, 5, 6, 7
Risk 2: Pins becoming displaced during transport leading to driver/passenger injury	8

Control Measures:

1. Organisational measures should be taken to reduce the need for manual handling.
2. Mechanical/ergonomic aids should be used where possible.
3. All surveyors that are required to carry equipment should undergo a recognised manual handling training programme, refreshed at intervals not exceeding three years.
4. Loads to be carried should be matched to surveyors' physical characteristics and attributes (age, height, weight, strength, etc.).
5. Surveyors must at all times take necessary steps to avoid overreaching and excessive twisting of the lumbar region.
6. Surveyors with a history of back injury should be suitably accommodated.
7. Appropriate personal protective equipment should be worn (gloves, boots with reinforced toecaps, etc.).
8. The storage location of pins in vehicles should be segregated with either a partitioning screen or other similar device so as to ensure pins that become displaced during transit do not cause injury to the driver or passengers.

Corresponding Picture Representation:

H.2C: Using a Total Station Instrument

Associated Risk(s)	Controls Required
Risk 1: Musculoskeletal damage due to manual handling of the instrument	1, 2
Risk 2: Ocular injury due to emitted laser beams from the instrument	3, 4, 5
Risk 3: Ocular phototraumatism due to magnifying proprieties of the instrument	6
Risk 4: Personal injury due to the instrument falling from its tripod	7, 8
Risk 5: Trips/falls over the instrument's tripod legs	9
Risk 6: Fire or electrical shock from inappropriate use of the instrument	10, 11, 12, 13, 14

Control Measures:

1. All surveyors that are required to carry equipment should undergo a recognised manual handling training programme, refreshed at intervals not exceeding three years.
2. The instrument should be carried in a suitable case, preferable equipped with adjustable double back straps.
3. Surveyors should be suitably trained in the laser emitting properties of the instrument.
4. Warning laser decals should be clearly displayed.
5. Caution should be exercised when using the instrument in proximity to the public or operatives who may be unfamiliar with the machine's laser function.

6. Caution should be exercised when using the telescopic lens to sight targets on hilltops, bridges, rooftops and other such elevated positions as such upwards sighting trajectory may cause ocular phototraumatism.
7. The instrument should be firmly fixed to the tripod head and the central fixing screw tightened.
8. The tripod legs spikes should be firmly anchored to the ground.
9. The instrument and tripod's position should be clearly highlighted with cones, warning tape and other such devices as necessary.
10. The instrument should not be disassembled or repaired by an untrained individual.
11. Power cords and cable should be examined before use.
12. The instrument must not be used in a potential explosive atmosphere as it is not intrinsically safe.
13. Battery transformers must never be covered by an obstructing material or substance that does not allow heat to dissipate sufficiently when charging.
14. Best practice in the construction industry suggests that only 110V power should be used onsite. As a consequence, all electrical charging of total station batteries should be done off site in a facility that has an appropriate 220V supply.

Corresponding Picture Representation:

H.2D: Working near Live Traffic

Associated Risk(s)	Controls Required
Risk 1: Surveyors being struck by public vehicles	1, 2, 3, 4, 5, 6, 7, 8, 9
Risk 2: Surveyors vehicles/equipment being struck by public vehicles	10, 11
Risk 3: Surveying equipment impacting on carriageways	12

Control Measures:

1. When work in the vicinity of live traffic cannot be avoided, organisational measures should be taken to minimise the length of time surveyors have to work in such areas.
2. Traffic management provisions to ensure surveyors' wellbeing must be established in accordance with the provisions of the Department of Transport's Traffic Signs Manual (Chapter 8: *Temporary Traffic Measures and Signs for Road Works*).
3. Competent operatives who have undergone SOLAS Construction Skills Certification Scheme (CSCS) Signing, Lighting and Guarding training must be used to setup and maintain traffic management systems.
4. Lateral and longitudinal safety zones of sufficient dimension must be established.
5. All traffic management provisions must be regularly inspected and suitably maintained throughout the duration of works.
6. Surveying work must be suspended if traffic management provisions are damaged in any way.

7. At a minimum, surveyors must wear hi-viability EN 471 Class 2 jackets or vests at all times.
8. EN 471 Class 3 hi-visibility clothing should be worn when working on high-speed roadways and when working at night.
9. In the event of an inability to install traffic management provisions, alternative means of protection should be considered (lorry mounted crash cushions, operative with the sole function of serving as a lookout for errant vehicles, etc.).
10. Surveyors' vehicles must not be parked in a manner that obstructs roadways.
11. Surveying vehicles should be conspicuous in colour and fitted with appropriate signs and flashing beacons.
12. Surveying equipment, where possible, should be positioned away from live carriageways. If this is not possible, equipment should be positioned at locations when in the event of falling/toppling it would not inadvertently land in the path of oncoming vehicles.

Corresponding Picture Representation:

H.2E: Hammering Control Points

Associated Risk(s)	Controls Required
Risk 1: Surveyors being struck by displaced nails	1
Risk 2: Members of the public/other operatives being struck by displaced nails	2
Risk 3: Impact injuries to hands	3
Risk 4: Falls/trips over protruding nail heads	4

Control Measures:

1. Surveyors must wear appropriate protective eyewear during all hammering tasks.
2. Public screen barriers should be used as necessary.
3. Surveyors must exercise due caution when using a hammer — the use of impact-resistant gloves should be used as necessary
4. Nails heads must be hammered flush with the pavement so as not to create a trip hazard.

Corresponding Picture Representation:

H.2F: Working near Plant and Machinery

Associated Risk(s)	Controls Required
Risk 1: Surveyors being struck/crushed/entangled by plant or machinery	1, 2, 3, 4, 5, 6, 7, 8

Control Measures:

1. Organisational measures should be taken to segregate operating plant and machinery from areas were surveying is taking place.
2. Surveyors must exercise due caution when working near plant and machinery.
3. Surveyors must not enter the working zone of any machine without first having safely notified the machine operator of their presence.
4. When it is necessary for surveyors to use dumpy levels, total stations, or other equipment that reduces peripheral vision, the use of a lookout operative may be necessary when working near plant or machinery.
5. Plant and machinery must only be operated by competent individuals who hold a valid training certificate/card/ticket.
6. Plant and machinery must be certified in accordance with all statutory requirements.
7. Plant and machinery safety inspections must take place at prescribed intervals.
8. All auxiliary safety devices must be operational on construction plant and machinery.

Corresponding Picture Representation:

H.2G: Hammering Steel Pins

Associated Risk(s)	Controls Required
Risk 1: Strikes to underground utility services	1
Risk 2: Impact injuries to surveyors from sledge hammers	2, 3, 4, 5, 6, 7
Risk 3: Repetitive strain injuries from frequent use of a sledge hammer	8

Control Measures:

1. All work near underground services must be performed in accordance with the Health and Safety Authority's *Code of Practice for Avoiding Danger from Underground Services* (2nd edition, 2010).
2. Sledge hammers should be of an appropriate weight for the user.
3. Sledge hammers should be of good construction and with no apparent defects.
4. Pins should be pointed to allow smooth ground penetration and less hammering,
5. Adequate rest periods should be organised and taken.
6. First aid kits should contain dry ice bags suitable for treating impact injuries.

7. If a second person is required to hold a pin for stability when hammering, their grip should be formed at a low level and only held until the pin has penetrated the ground.
8. Individuals engaged in hammering tasks should be regularly rotated and any indication of repetitive strain injury should be reported to site management.

Corresponding Picture Representation:

H.2H: Using a Digging Bar

Associated Risk(s)	Controls Required
Risk 1: Strikes to underground utility services	1, 2

Control Measures:

1. All work near underground services must be performed in accordance with the Health and Safety Authority's *Code of Practice for Avoiding Danger from Underground Services* (2nd edition, 2010).
2. Non-insulated digging bars should not be used; digging bars insulated to BS8020:2002 standard are required.

Corresponding Picture Representation:

H.2I: Projecting Steel Pins

Associated Risk(s)	Controls Required
Risk 1: Trips and falls leading to cuts/ abrasions from steel pins	1, 2
Risk 2: Falls from a position of height onto steel pins leading to impalement	3, 4

Control Measures:

1. Protective mushroom caps must be placed on all surveying pins.
2. Protective mushroom caps must be the correct size to accommodate the pin — additional fixing tape should be used in high wind conditions or as necessary.
3. Means of fall protection should be provided at positions of height.
4. When there is a risk of falling from a position of height and landing on a surveying pin, specific impact-resistant mushroom caps must be used on all projecting surveying pins.

Corresponding Picture Representation:

H.3A: Using a dumpy level

Associated Risk(s)	Controls Required
Risk 1: Anatomical misalignment while using a dumpy level	1
Risk 2: Ocular phototraumatism due to magnifying proprieties of the instrument	2
Risk 3: Trips/falls over the instrument's tripod legs	3

Control Measures:

1. Attempts should be made to position the instrument at eye level to eliminate the need for stooping.
2. Caution should be exercised when using the level to sight targets on hilltops, bridges, rooftops and other elevated positions as such upwards sighting trajectory may cause ocular phototraumatism due to the position of the sun.
3. The level and tripod's position should be clearly highlighted with cones, warning tape and other such devices as necessary.

Corresponding Picture Representation:

H.3B: Using a Measuring Staff

Associated Risk(s)	Controls Required
Risk 1: Holding an extended staff	1, 2
Risk 2: Potential shearing trap as a result of the staff's sliding-lock mechanism	3
Risk 3: Use in hazardous areas	4

Control Measures:

1. The measuring staff should not be used in areas where inadvertent contact with overhead services could be made.
2. Caution must be exercised when raising the measuring staff in inclement weather due to the potential risk of it slipping from the operative's hands and causing damage to buildings, vehicles or pedestrians in the surrounding area.
3. Caution must be exercised when extending and retracting the measuring staff so as to ensure fingers do not become trapped.
4. Measuring staffs that are dipped into areas that have the potential to contain biological hazards (e.g. sewers) must be appropriately disinfected after use.

Corresponding Picture Representation:

H.3C: Surveying in Excavations

Associated Risk(s)	Controls Required
Risk 1: Surveyors inadvertently falling or driving into excavations	1, 2, 3, 4, 5
Risk 2: Accessing/egressing excavations	6, 7
Risk 3: Flooding of excavations	8, 9, 10, 11
Risk 4: Asphyxiation in excavations	12, 13, 14
Risk 5: Collapse of excavations	15, 16, 17, 18, 19, 20, 21
Risk 6: Surveyors being struck by excavators and/or associated digging equipment	22, 23

Control Measures:

1. When possible, edge protection should be erected around the perimeter of an excavation even when digging.
2. Excavations must not be left unattended when open (fence or delineate during work breaks, backfill at the end of each working shift).
3. In times of reduced visibility or if working in hours of darkness, auxiliary lighting in the vicinity of excavations should be considered.
4. Excavation warning signage should be erected as necessary.
5. Vehicles and site plant must be kept as far away as possible from excavations through the use of barriers, berms, cones, warning tape, etc.
6. If surveyors are required to work in an excavation, the excavation should have an adequate and swift means of access and egress.
7. Ladders used for access/egress must be suitably tied or footed.
8. All excavations must be suitably dug to prevent the inrush of water.

9. Operatives must not work in excavations that contain hazardous levels of water.
10. Submersible extraction pumps should be used as necessary (petrol or diesel plant should be situated in open, well-ventilated areas and not in the confines of the excavation).
11. Work in excavation should be suspended immediately at the onset of flash flooding.
12. Excavations must be dug in a manner that allows maximum ventilation.
13. Petrol or diesel pumps, generators etc. should be situated in open, well-ventilated areas and not in excavations.
14. Gas detection equipment must be used when necessary.
15. All excavations must be dug and maintained in accordance with the requirements of the Health and Safety Authority's *Guide to Safety in Excavations* (2007).
16. All excavations where surveyors are expected to work must be protected from a fall or dislodgement of earth, rock or other such material by appropriate shoring, battering, or other suitable means as is necessary.
17. Trench boxes and other auxiliary safety equipment should be used as necessary.
18. Surveyors must never enter a hazardous unsupported excavation or trench and must never work ahead of supports.
19. Excavated material must not be stored near the top of an excavation.
20. All stockpiled material and excavated slopes must be battered safely.

21. Excavations must be inspected by a competent person and the results of such inspection entered on an AF3 Form[122] at the start of each shift; after an accidental fall of any material; and after any event likely to affect the strength or stability of the excavation.
22. Surveyors must not enter the working area of mechanical excavators without first having safely notified the operator of their presence.
23. Surveyors should not enter excavations where mechanical excavators are digging.

Corresponding Picture Representation:

[122] An AF3 Form is a Health and Safety Authority approved form for the thorough examination of excavations, shafts, earthworks, underground works, tunnels, cofferdams and caissons as prescribed under Regulation 52(3) and Regulation 60(2) of the Safety, Health and Welfare at Work (Construction) Regulations 2013 (S.I. No. 291 of 2013).

H.3D: Work at Height

Associated Risk(s)	Controls Required
Risk 1: Falls from positions of height	1, 2, 3, 4

Control Measures:

1. Organisational measures should be taken to avoid the need for surveyors to work at height where possible.
2. If work at height is unavoidable, appropriate means of fall restraint must be in place (guardrails, fall restraint harnesses and lanyards, etc.)
3. If it is not reasonably practicable to install means of fall restraint, the use of fall arrest equipment should be considered (fall arrest harnesses, bean bags, safety netting, etc.).
4. If fall arrest equipment is being used an adequate emergency recovery plan should be developed and tested. First aid personnel should also be familiar with the procedures for dealing with suspension trauma (orthostatic intolerance)

Corresponding Picture Representation:

H.3E: Pulling String Lines and Taking Dip Levels

Associated Risk(s)	Controls Required
Risk 1: Hand injuries due to the string line being snagged by passing site vehicles	1, 2, 3
Risk 2: Trips/falls over a taut string line	4

Control Measures:

1. A hi-visibility string line should be used, appropriately contrasting in colour to that of the road base.
2. A warning cone, equipped with an appropriate sign should be placed in front of the string line to warn passing site vehicles of the line's presence.
3. Operatives tasked with pulling the string line must wear appropriate protective gloves.
4. When not in use, string lines must be retracted and appropriately stored.

Corresponding Picture Representation:

10.4 Recommendations —An SSWP for the entire GES community

10.4.1 Current Drawbacks

Although undoubtedly a useful tool if developed, the SSWP as outlined in the preceding pages is not a paragon of perfection in its current paper-based guise. What at first would appear to be a simple one-page tick-the-box check sheet, in practice, requires users to consult a supplementary detailed handbook that explains all the necessary control measures as shown on pages 213 - 245. The consequence of this gives rise to the possibility of the user failing to consult the said handbook — be it due to perceived familiarity with the picture representations and underpinning control measures or human resolve to follow the idiom of simply "ticking-the-box" and moving on with the task. Anecdotal evidence would suggest that the latter may be true for many existing construction related SSWPs.

10.4.2 Current Indications

To test the aforementioned theory, a scoping study was conducted. The study involved leaving the academic setting and carrying out research in a commercial construction environment, as this is the only current known area where existing construction SSWPs are in use. Six companies and four sole traders engaged in construction activity in the Leinster region that use Health and Safety Authority (HSA) approved SSWPs were randomly selected [123]. The study involved participants completing an administered questionnaire, the aim of which was to gain feedback on how users interact with SSWPs in the field. As the process was conducted in a live construction environment, interface times were typically short in duration with each

[123] Participants used a combination of HSA approved House Building SSWP (2005), Ground Works SSWP (2007), and Civil Engineering SSWP (2005) forms.

consultation taking less than 10 minutes. Of the ten participants, 9 were employed in a supervisor capacity with the remaining 10 employed in an operative position. All participants worked for small organisations with less than 11 employees. Efforts were made to find GES contractors that used existing HSA approved SSWPs but this was not achieved. The primary areas of construction activity of those that participated in the study is summarised in Table 1.6 below.

Table 1.6 Primary Area of Construction Activity

Primary Area of Activity	Numbers Interviewed
Plumbing works	2
Electrical works	3
Civil engineering works	2
Carpentry works	1
Brick & block laying works	2

In each case, seven opening questions were asked, namely:

1. Do you find SSWPs to be a beneficial tool that aids in general health and safety management?
2. Do you find the SSWP you are using to be of relevance to your profession?
3. Do you keep a copy of the supporting SSWP booklet that lists the control measures on site?
4. Do you consult the SSWP supporting booklet when filling out the SSWP check sheets?
5. Do you know all the supporting control measures for the pictograms “off by heart”?

6. Can you list the control measures for the following pictograms? (3 randomly chosen pictograms were selected and shown to the participants)
7. Would you see benefit in the development of an electronic application (app) version of an SSWP that could be completed on a smartphone or electronic tablet?

Responses to the presented questions were as follows:

Question 1: Do you find SSWPs to be a beneficial tool that aids in general health and safety management?

70% of respondents stated that they do find SSWPs to be of benefit in the management of health and safety. Reasons given by those who found no benefit in SSWPs consisted of: "Additional layers of paperwork", "A lot of stuff not relevant to what we do", "Not fully sure how they're supposed to help".

Question 2: Do you find the SSWP you are using to be relevance to your profession?

60% of respondents stated that they do find the SSWP they are using to be of relevance to their profession. Reasons given by those who found the SSWP to be of lesser relevance comprised: "more suited to big sites", "very little for electricians", "nothing to really do with plumbing".

Question 3: Do you keep a copy of the supporting SSWP booklet that lists the control measures on site?

60% of respondents stated that they do keep a copy of the supporting SSWP booklet on site. 30% stated that they do not, and 10% stated that they were unsure.

Question 4: Do you consult the SSWP supporting booklet when filling out the SSWP check sheets?

80% of respondents stated that they do not consult the SSWP supporting booklets. 20% stated that they do consult the booklets.

Question 5: Do you know all the supporting control measures for the pictograms "off by heart"?

80% of respondents stated that they do not know all the supporting control measures. 20% of respondents stated that they do know all the control measures.

Question 6: **Can you list the control measures for the following pictograms? (3 randomly chosen pictograms from existing Health and Safety Authority SSWPs were selected and shown to the participants)?**

Given the feedback obtained from Question 5, only the 20% of respondents who claimed to have memorised all the control measures were asked to complete this question. The ensuing answers did not correspond with all the control measures listed in the Health and Safety Authority's SSWP support booklet.

Question 7: Would you see benefit in the development of an electronic application (app) version of an SSWP that could be completed on a smartphone or electronic tablet?

80% of respondents stated that they would not see benefit in the development an electronic app. 20% stated that they would see benefit. Reasons given by those who saw no benefit included: “we don’t really use computers (endorsed by multiple respondents), “it would be safer to have the paperwork”, and “not sure how it would work”.

10.4.3 Scoping Study Conclusions

Responses demonstrate that the majority of those questioned find benefit in SSWPs, however, only slightly more than half believe they are of relevance to their individual professions. This would suggest that more non-generic SSWPs for individual construction professions are required. In relation to the supporting SSWP booklets, in most cases they are not being retained on site. The corollary of this sees SSWP check sheets being completed without consulting the aforementioned booklet. Of more significant concern is the fact the study demonstrated that those questioned were found not to fully comprehend the range of established control measures. This gives rise to the entire process being potentially discredited and turning the exercise into an ineffective “tick-the-box” procedure. In relation to remedying the problem, surprisingly, the respondents did not all support the development of an electronic SSWP. However it should be noted that the majority of those questioned were primarily engaged in activities that ostensibly have low interactions with computer technology (e.g. block laying, carpentry, plumbing) and responses to this question may be quite different if posed to a profession such as geodetic engineering surveyors that have a high level of computer interface — such conjecture is supported by the fact all those respondents in favour of a computer based application were electrical contractors.

In summary, the scoping study was small and only meant to serve as an empirical indication of SSWP practices in the construction industry. Results, however, suggest there is a clear need to change the way SSWPs are used.

10.4.4 Future Proposals

Although not supported by the majority of those questioned, development of an electronic format of SSWP is arguably the way forward. SSWPs are currently paper-based and therefore static in nature, a trait that is unfitting to an ever evolving, technology lead profession such as geodetic engineering surveying. Recent years have seen rapid proliferation in the number of downloadable applications available for smartphones and electronic tablets. Current estimates from leading retailers such as Apple Inc., suggest they have in the region of 2.2 million available applications in their stores, while Android Inc. claim 2.8 million. [124]

In relation to benefits, an electronic SSWP for the GES profession and students would have the potential to eliminate the need to retain and refer to supplementary handbooks. It also would have the ability to contain step-by-step detailed instruction, comprise much more thorough information, be more easily updated, and crucially, incorporate a failsafe to eliminate the "ticking of boxes" without first having assessed the precursory control measures. From a statutory health and safety perspective, legislators are recognising the construction industry's increasing reliance on electronic mediums. Regulation 3.4 of the Safety, Health and

[124] Correct as of May 2018.

Welfare at Work (Construction) Regulations 2013 (S.I. 291 of 2013) details how in instances where records, reports, certificates or other documents are required to be made and kept, it is sufficient compliance if the person concerned enters the record, report, certificate or other document into a computer and duly authenticates it as necessary, thus demonstrating support for the premise of technology lead health and safety management. Finally, the cost of developing such an application has the potential to be somewhat offset when the savings in raw materials, publishing, postage, etc., associated with a paper-based system are considered.

Undoubtedly, the development of such an application falls outside the scope of an autonomous research project such as this and the reader is reminded, as stated on page 212, that it would be imprudent to develop a fully operational SSWP for the GES profession without first conducting additional and thorough case studies in more diverse areas of construction (structural, commercial, residential, industrial, etc.). However, Figure 5.7- 5.9 overleaf illustrates how the proposed application could work for geodetic engineering surveyors.

Figure 5.7 *Proposed App – Screenshot 1*

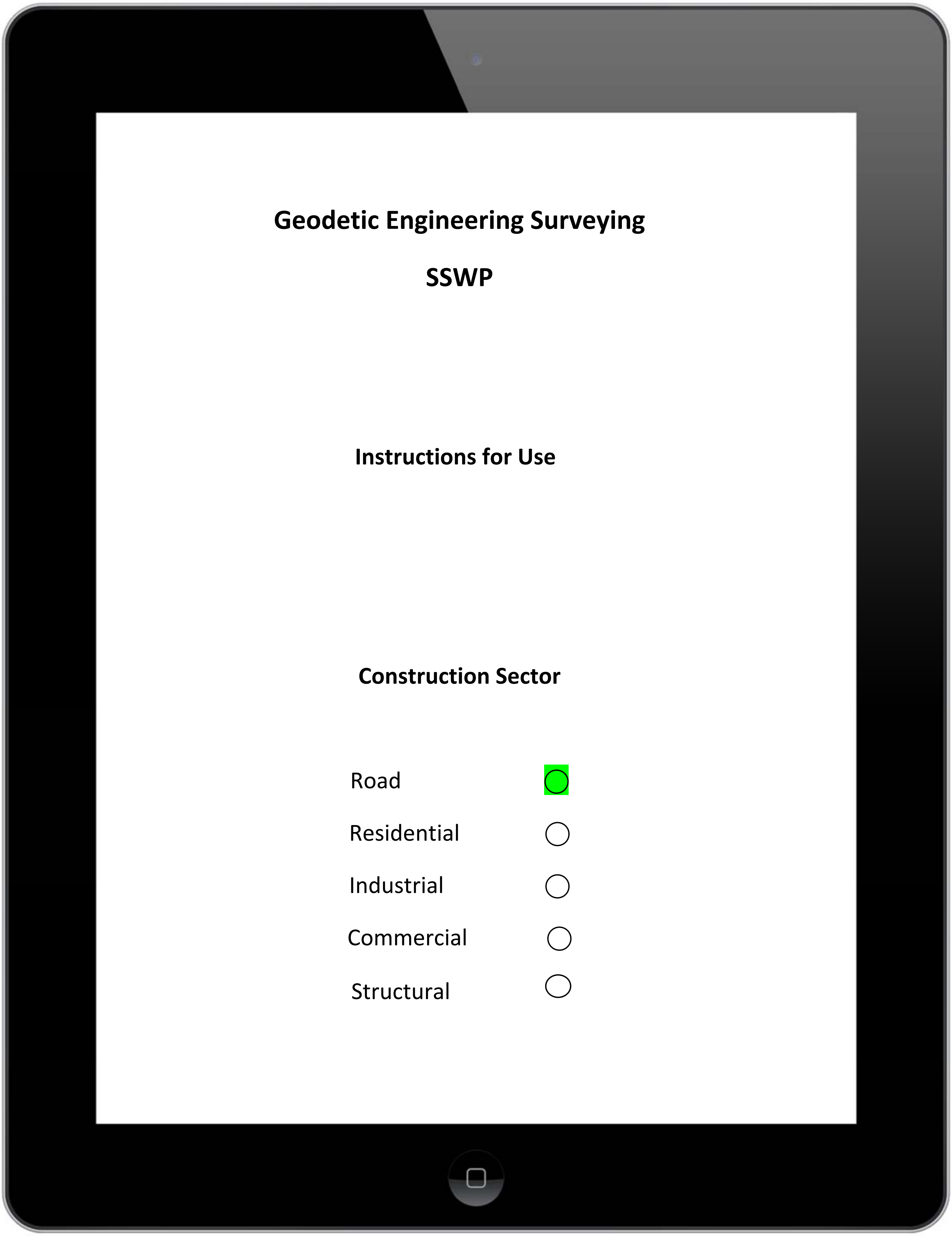

Figure 5.8 *Proposed App – Screenshot 2*

Figure 5.9 *Proposed App – Screenshot 3*

Use of a Total Station Instrument

Associated Risks and Control Measures (Select as Relevant)

Risk: Musculoskeletal damage due to manual handling of the total station instrument	**N/A**	**Applicable**
Control: All surveyors that are required to carry equipment should undergo a recognised manual handling training programme, refreshed at intervals not exceeding three years.		
Control: The instrument should be carried in a suitable case, preferable equipped with adjustable double back straps.		
Additional Controls Required:		

Risk: Ocular injury due to emitted laser beams from the instrument	**N/A**	**Applicable**
Control: Surveyors should be suitably trained in the laser emitting properties of the instrument.		
Control: Warning laser decals should be clearly displayed.		
Control: Caution should be exercised when using the instrument in proximity to the public or operatives who may be unfamiliar with the machine's laser function.		
Additional Controls Required:		

Risk: Ocular phototraumatism due to magnifying proprieties of the instrument	**N/A**	**Applicable**
Control: Caution should be exercised when using the telescopic lens to sight targets on hilltops, bridges, rooftops and other such elevated positions as such upwards sighting trajectory may cause ocular phototraumatism due to the position of the sun.		
Additional Controls Required: **Assessment completed by:**		

10.4.5 Usage

A developed electronic SSWP such as the one described would serve a dual purpose, being of use in both academic and occupational environments. Support for this can be found in the ease with which an electronic SSWP could be integrated into GES higher-level programmes — largely due to being a centralised, concise data source and requiring minimum lecturer expertise in health and safety to deliver. Moreover, because it provides a hazard listing and associated control measures, an SSWP can contribute significantly to risk assessments, method statements, task briefings, and even toolbox talks[125] for geodetic engineering surveyors in an occupational environment. Finally, should a GES practitioner be exposed to such an SSWP in their higher-level studies and again in a professional setting, their general level of safety awareness should increase through repeated exposure.

10.4.6 SSWP Validation

After an SSWP has been developed, the most appropriate way to determine its validity is through field testing. Using suitable consultees, the model's suitability should be thoroughly analysed. Such a review ought to be iterative in nature and comprise distribution, feedback, and redesign of the SSWP as necessary. The most appropriate way to attain this would again be a self-administered questionnaire appended to the developed SSWP, structured to elicit pertinent feedback on the

[125] A toolbox talk is an informal presentation to site operatives by site management on a relevant health and safety topic. Talks are typically short in duration and cover topics such as work-related hazards, risks, and safe operating procedures.

SSWP's applicability, suitability, usability, completeness, and general effectiveness.[126]

Presently, such attempts at accurate validation are not possible without a developed electronic SSWP to analyse.[127] Nevertheless, indications on the perceived effectiveness of the proposed system can be sought from experienced GES practitioners. It was decided to seek such indications from this demographic and not academics or students, as empirical research throughout this body of work has shown the former have little engagement with GES health and safety issues at present, and in up to 75% of cases, the latter have not been adequately introduced to the specific topic as part of their higher-level learning. The corollary of this sees GES practitioners being the most appropriately placed to make comment on a practical day-to-day operating system such as the proposed SSWP as there would be little point introducing a system for integration into higher-level learning for future professional life that has not been tested in the field.

To accomplish this, the idea of a focus group to discuss the merits and demerits of the proposed SSWP was first considered. This was dismissed due to early difficulties encountered in assembling enough participants to provide suitable diversity of perception, and logistical problems in convening such a gathering.[128] The previously trialled method of a self-administered questionnaire delivered to a representative sample was considered, but was deemed too constricting as answers would be limited to the parameters of the questions posed and therefore not ideal for

[126] Ideally, given the rapidly changing nature of the GES sector, protracted analysis in the form of a longitudinal review aimed at proving continuing validity should also be considered.
[127] As detailed earlier in the chapter, readers are reminded that it is not just time and financial constraints that placed the development of a working electronic SSWP outside the scope of this study, but also the additional multi-sectorial case studies required to provide sufficient data for the system's complete formation.
[128] Peek and Fothergill (2009) conclude that there is variation in the perceived ideal number of participants required for a focus group, but suggest 6–10 is preferable; this is supported by Morgan (1997) and Litosseliti (2003).

discussion of a concept. Moreover, without the aid of a fully developed model, it was felt that those being consulted may encounter difficulty understanding the workings of an electronic application described solely on paper.

Ultimately, it was decided to use semi-structured interviews and a mock-trial approach to elicit feedback as it was felt such an approach would allow for suitable exploration of central themes, topical discussion, and the freedom for ad hoc trajectories of debate. In addition, semi-structured interviews were felt to be most suited to an informal setting such as a live construction environment.

Potential participants were identified by the author using a process of professional networking in the industry. The profile of participants was limited to individuals primarily engaged in GES in the Leinster region, with no other qualifying criteria being used. However, it should be noted that all participants either worked in small surveying companies (≤ 3 employees) or were self-employed. Though not by design, all participants were males aged 25–52.

In total, five individuals participated in the interviews, which were conducted on a one-to-one basis during January-April 2016 and typically lasted less than 15 minutes. The process began with the interviewer giving an overview of research to date and details of the study's aims and objectives.[129] A sample Health and Safety Authority-approved SSWP and supplementary booklet were then shown to participants and their contents explained. Following on from this, a paper-based example of the proposed electronic SSWP for the GES profession was shown (as detailed on pages 253 to 255) and explained to the participants. Any queries posed

[129] In an attempt to build rapport, the interviews commenced with "settling" questions and a brief general discussion on the Irish construction sector, health and safety, changes in the industry since the economic recession, and other themes non-central to the research.

were answered and clarified, and it was confirmed that participants understood the proposed new SSWP. The following opening questions were then put forward:[130]

Question 1: What is your job title?

Question 2: What GES/construction sector do you work in?

Question 3: How long have you worked as a surveyor?

Question 4: Have you ever used an SSWP before, and if so, what has been your level of involvement?

Question 5: Are you aware of any safety aids similar to that of an SSWP for surveyors?

Question 6: How comfortable are you with mobile technology such as smart phones and electronic tablets?

Question 7: Based on the paper-based SSWP example you have been shown, do you think it would be advantageous to make this into an electronic-based application?

Question 8: Based on the example of the proposed electronic SSWP for GES practitioners you have been shown, do you think such a system would be of benefit to you in your work place?

[130] Having been shown an example and having the workings of the proposed new system explained, participants were given a paper copy of the application as an *aide-mémoire* to consult as necessary during the interview.

Question 9: Do you think such a system is needed in the GES industry?

Question 10: How could the proposed system be improved?

The following narrative is a synopsis of participant responses:

Question 1: What is your job title?

All respondents confirmed they worked as geodetic engineering surveyors.

Question 2: What GES/construction sector do you work in?

The majority (80%) stated that they were employed on civil engineering projects and the minority (20%) on building projects.

Question 3: How long have you worked as a surveyor?

Nearly all participants had considerable experience (5+ years) working as GES professionals, with one exception who had just over one year's experience.

Question 4: Have you ever used an SSWP before, and if so, what has been your level of involvement?

All participants confirmed they had seen SSWPs before the interview, but none had ever used such a system. Reasons given for non-use included: "*not being relevant to what we do*" and "*I thought they were just for the Safety Officer to fill out*". Of potential note was the repeated witticism of the forms being a tick-the-box exercise only used to keep safety officers contented. However, on asking those participants if they felt the tick-the-box element was too simplistic and whether the system should require the user to write more detailed responses, they all said no. Humorous judgements were also given on the use of pictogram representations, with one participant saying: "*I don't have time to doodle with them* [*sic*] *cartoons*". When asked if he felt the use of artistic representations devalued the more serious intention of an SSWP, he said yes.

Question 5: Are you aware of any safety aids similar to that of an SSWP for surveyors?

All participants answered no to this question. When asked if they thought the GES profession was occupationally hazardous, the majority of participants seemed somewhat nonchalant in their responses. Replies included: "*It's no different than any other construction job really*"; "*Depends if you're being aware and taking your time*"; "*A bit, I suppose*". However, two of the respondents were more resolute and stated that they do consider the profession to have inherent hazards. When queried further, they described historical accidents and near misses. One participant also stated how "*younger surveyors haven't a clue when it comes to working near traffic*". But when asked if he thought it was a problem solely with junior surveyors, he answered no.

Question 6: How comfortable are you with mobile technology such as smart phones and electronic tablets?

All participants said they were either comfortable or very comfortable with such technology. One pointed out how their profession has become highly computer-centred, thus giving support to the hypothesis that a technology-led profession would be comfortable with an electronic SSWP (as put forth on page 250). All participants confirmed they used smart phones; none, however, used an electronic tablet on site.

Question 7: Based on the paper-based SSWP example you have been shown, do you think it would be advantageous to make this into an electronic-based application?

All participants agreed that such a system would be more advantageous in electronic format. Reasons given included: "*easier to manage*"; "*easier to change*"; "*no need to flick through an extra handbook*" and "*everything is going electronic now*". However, one individual pointed out that owing to local site rules on the particular job where he was employed, mobile phones could only be used in designated areas. And although meant in jest, another individual alluded to the real possibility that "*safety officers wouldn't accept the excuse that the battery went flat*" (on an electronic device that would house the application). But when asked, all responded that they did not see the need to have a paper-based backup system.

Question 8: Based on the example of the proposed electronic SSWP for GES practitioners you have been shown, do you think such a system would be of benefit to you in your work place?

All participants confirmed that they thought such a system would be of benefit. When asked why, reasons included:

- "*simple to follow*"
- "*would reduce the time spent at risk assessment*"
- "*gives a good indication of what to look out for*" (in health and safety terms)
- "*would make you be aware of the dangers*"

- "*It would offer some line of defence if things went wrong. At least you could say you looked at the work and made an assessment.*"

Question 9: Do you think such a system is needed in the GES industry?

Responses to this question consisted of:

- "*Yes*"
- "*Yes, I suppose*"
- "*Yes*"
- "*Don't know, to be honest — I'd have to see it working*"
- "*Yes.*"

Question 10: How could the proposed system be improved?

One participant seemed to contradict his prior answers from Question 8, suggesting the proposed system was "*a bit hard to understand*" and could be further simplified. One participant suggested the proposed system needs to be free of charge. One participant suggested that the documented hazards do not adequately address all those that can be found by a geodetic engineering surveyor in a civil engineering environment and would need to be expanded.[131] Two respondents had no suggested changes.

When asked if it would be better to develop a standalone application for each surveying sector (civil, building, structures, etc.) or have one application that encompasses all GES sectors, respondents felt there should only be one application. The reasoning behind this offered by one participant was that there is frequently a

[131] Further discussion with the interviewee highlighted additional hazards that were not encountered in the case study used to form the proposed SSWP.

crossover of surveying in sectors, so more than one electronic application would be cumbersome.

Finally, when asked, all participants confirmed that they would be interested in seeing a working model of the proposed system.

10.4.7 Chapter Findings and Conclusion

Based on the example shown, there was full support for the further development of the proposed electronic SSWP for the GES sector. Although the consultation was small in number, those interviewed were suitably qualified to answer the questions posed. It would be remiss not to document that participants were at times somewhat reticent and not overly forthcoming with suggestions. Yet, on review, answers to posed questions were found to be succinct and valuable.

Findings showed that participants were familiar with the concept of SSWPs, but had no experience in using such systems. This is unsurprising, as existing SSWPs have extremely limited relevance to the GES profession, with no sector-specific models currently available.

Comments describing existing SSWPs in a non-electronic format as a tick-the-box exercise gives credence to earlier conjectures (p. 246) and is a situation that could be overcome by introducing an electronic-based model. Similarly, perceptions of the pictograms as childish suggest that photographs, as used in the proposed example, might be more appropriate. Those interviewed had mixed feelings on the level of danger in their profession — some with more conviction than others. Yet all saw benefit in the proposed electronic SSWP. That said, there were suggestions that the proposed system was somewhat difficult to understand, which could be overcome if a developed model were made available. The issue of the cost of the proposed SSWP was also highlighted, with suggestions being made that it should be free of charge to promote uptake — a logical suggestion given the primary aim of making the GES's workplace safer. From a critical perspective, there were also suggestions that the provided example did not adequately address all the hazards that can be found in a civil engineering environment. Such feedback was expected, as the developed proposal was derived from a sector-specific case study/sequential task analysis and further analysis would be needed to develop a complete working model. As anticipated, those questioned supported this assertion and felt that a developed application would need to contain information for all surveying sectors and not just from a civil engineering road project.

From a user perspective, all participants confirmed that they were content to use mobile technology and would find benefit in an electronic system over a paper-based model. However, it was highlighted that the use of mobile phones is prohibited on certain construction sites and that this could prevent use of the proposed application. Conversely, given the level of detail, text, pictures, etc., that the system would utilise, in all probability it would be more suited to tablet-sized devices. Whether these devices are also being widely prohibited on construction sites was not ascertained, but the idea seems unlikely and somewhat unreasoned for GES professionals when one considers the numerous items of standard surveying equipment that are equipped with computer screens, data loggers, keypads, etc. Similarly, concerns raised over batteries going flat on smart devices that provide the platform for an electronic SSWP should not be overly problematic for surveyors, as most existing surveying equipment needs to be charged on a nightly basis.

In conclusion, the emergent theme was one of support for the proposed system and clear encouragement for further development. Accordingly, the next steps at achieving validation would be to broaden the case study into other areas of GES, and from there, develop a full working model of an electronic SSWP that could be introduced into higher-level learning and the professional GES environment.

Going forward, regardless of what approach is taken to protect the occupational health and safety of geodetic engineering surveyors, they are a profession that plots and shapes the contours and cornerstones of our society and are as permanent as the three-out-of-four land surveyors who preside at Mount Rushmore – George Washington, Abraham Lincoln, and Thomas Jefferson – all of whom if had they been involved in an occupational misfortune that shortened their lives may have made our world a different place. With this in mind, and recalling the latter surveyor's inalienable right in his Declaration of Independence to "*life, liberty and the pursuit of happiness"*, surely the modern-day surveyor ought to be afforded the right to education on how to protect their occupational health and safety?

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APPENDICES

Appendix 1: Transcription of the first scoping e-mail sent to course directors/lecturers

Dear _________________,

I am a postgraduate research student at National University of Ireland, Galway. As part of a current investigative study, I am looking to collate data on the number of higher-level courses that offer either modules or classes in the subject of geodetic engineering surveying. As a result, can you please be so kind as to inform me whether or not programme ______________________________ contains such tuition.

If this programme does contain elements of geodetic engineering surveying, please indicate whether the classes are given on a practical or theoretical basis, and if possible give an estimation of the number of hours spent teaching the subject.

Thanking you in advance for your invaluable assistance.

Yours sincerely,

Oisin Kearns

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Appendix 2: Transcription of the second e-mail sent to course directors/lecturers

Dear _________________,

My name is Oisin Kearns and I am a postgraduate research student at National University of Ireland, Galway. You may recall I contacted you in _____________ of last year seeking information as to whether or not the __________________in _______________offered by your Department contained a taught element in geodetic engineering surveying.

As a follow on to this enquiry, I have prepared a short questionnaire (15 questions) examining health and safety tuition on higher-level courses in (or that contain elements of) geodetic engineering surveying.

I've structured the questions so as to take up the least amount of your time possible (most answers only require a Yes/No response) and would be indebted to you if you would complete it. Should you agree, please click on the following hyperlink to access the questionnaire: ___________________________________

Any information gathered shall be treated in the strictest of confidence and used solely to assimilate an overview of this educational sector. Should you have any queries or require further information, please do not hesitate to contact me.

Thanking you in advance,

Oisin

(Contact details given....)

Appendix 3: Transcription of the third e-mail sent to course directors/lecturers

OÉ Gaillimh
NUI Galway

Dear _________________,

You may recall I sent you an email containing a hyperlink to an electronic questionnaire that attempted to gain feedback from you in relation to the tuition of geodetic engineering surveying (construction land surveying) on the _____________________________ offered at your college.

If you have already completed this questionnaire, may I thank you and ask you to please ignore this email. However, if you have not, I would ask you to consider doing so as your feedback would greatly enhance my research.

The questionnaire can be accessed by clicking on the following hyperlink and should take no more than five minutes of your time, as there are just 15 questions and most only require a Yes/No response:

Hyperlink: ____

Yours sincerely,

Oisin Kearns

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Appendix 4: Hardcopy transcription of the distributed electronic questionnaire

NUI Galway OÉ Gaillimh

QUESTIONNAIRE

The aim of this study is to quantify the level of tuition students receive in occupational health and safety while attending higher-level programmes that contain taught elements in geodetic engineering surveying. For the purpose of this questionnaire, geodetic engineering surveying can be defined as the process of surveying land with a view to positioning and enabling aspects of civil and building construction.

THIS SECTION DEALS WITH GENERAL COURSE INFORMATION

1. Average number of graduates per year: ____________________

2. Approximate ratio of graduating males to females:

   ________ % Male

   ________ % Female

3. Is occupational health and safety taught on the programme?

   ☐ YES

   ☐ NO

If you answered *NO* to question 3, please skip to question 7. If you answered *YES*, complete questions 4–6 first.

4. Are the occupational health and safety classes a component of a module or a standalone module?

☐ Component

☐ Standalone

(a) If occupational health and safety is a component of a module, approximately how many hours are spent teaching the subject?

≤ 10 ☐ 11-20 ☐ 21-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐ 61-70 ☐ 71-80 ☐ 81+ ☐

☐ Non-applicable question

(b) If occupational health and safety is a standalone module, how many ECTS credits are assigned to the subject? ___________________

☐ Non-applicable question

5. Are the occupational health and safety classes elective or mandatory for students?

☐ Elective

☐ Mandatory

6. In addition to general occupational health and safety information presented on the programme, is there any particular information given on health and safety issues exclusively for geodetic engineering surveyors?

☐ YES

☐ NO

THIS SECTION DEALS SPECIFICALLY WITH THE GEODETIC ENGINEERING SURVEYING ASPECT OF THE COURSE

7. Do students ever go on work placement with geodetic engineering surveyors?

☐ YES

☐ NO

8. If a student required specific health and safety information for geodetic engineering surveying, which source(s) would you advise them to consult? (Select more than one if appropriate)

☐ Health and Safety Authority

☐ Health and Safety Executive (UK)

☐ Royal Institute of Chartered Surveyors

☐ Irish Society of Surveyors

☐ Other source; please specify_______________________________________

9. Safe Systems of Work Plans (SSWP) are now commonplace in the construction industry. Do you think an SSWP for geodetic engineering surveyors would be beneficial? (If you are unfamiliar with these systems, please click on the following hyperlink for an example: http://www.youtube.com/watch?v=A4lLy1WWbZo)

☐ YES

☐ NO

10. If an SSWP was developed for geodetic engineering surveyors, would you consider integrating its content into your programme?

☐ YES

☐ NO

11. In your opinion, would the development of a health and safety Code of Practice for the geodetic surveying profession be beneficial?

☐ YES

☐ NO

12. In the UK, a Construction Skills Certification Scheme (CSCS) is in operation. This scheme offers skill cards to geodetic engineering surveyors and chainmen following completion of a prescribed course on issues that include safety. Do you think such a scheme would be of benefit for these occupations in the Republic of Ireland?

☐ YES

☐ NO

13. Do you consider the geodetic engineering surveying profession to be an essential component of the construction sector?

☐ YES

☐ NO

14. Are you aware that the Safety, Health and Welfare at Work (Construction) Regulations (S.I. No. 504 of 2006) exclude site surveying from the definition of what constitutes '*construction work*'?

☐ YES

☐ NO

15. Please indicate on the following scale approximately how much consideration you have given to the occupational health and safety of geodetic surveyors prior to the completion of this questionnaire:

No Consideration—Infrequent Consideration—Occasional Consideration—Frequent Consideration—Very Frequent Consideration

Thank you for taking the time to complete this questionnaire. There now follows a section for any comments you may have:

____

____

____

____

Please indicate if you would like to see the overall results of this research when completed: ☐ YES ☐ NO

If you selected YES, enter your name and email address

____

TLS